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A UNIFIED ACCOUNT OF CONDITIONED PHONOLOGICAL ALTERNATIONS: EVIDENCE FROM GUÉBIE

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This article expands on cophonologies by phase, a model of the interface between morphology and phonology, which was introduced in Sande & Jenks 2018. The crucial innovation of cophonologies by phase is the enhancement of lexical or vocabulary items to include morpheme-specific constraint weights. These weights modify the default phonological grammar of the language only in the domain of evaluation that contains the triggering morpheme, where domains are determined by syntactic phase boundaries. The interactions of the default grammar and morpheme-specific constraint weights function as cophonologies (Orgun 1996, Anttila 2002, Inkelas & Zoll 2005, 2007) in that they result in morphosyntactic construction-specific phonological grammars. Here, cophonologies by phase is shown to provide a unified account of syntactically, morphologically, and lexically conditioned phonological alternations, phenomena that have been analyzed using distinct theoretical tools in previous work. In order to demonstrate the application of cophonologies by phase to a diverse set of interface interactions, this article considers three case studies of phonological alternations in Guébie (ISO: gie), an endangered Kru language, each conditioned by a different set of extraphonological factors.*

Keywords: morphologically conditioned phonology, phases, locality, tone, vowel harmony, Guébie

1. Introduction. Phonological alternations can be conditioned by a diverse range of factors. Some of these factors are purely phonological, while others are external to phonology. Phonological sensitivity to a specific lexical or functional morpheme is not uncommon, and various frameworks have been developed to model this type of morphologically conditioned phonology: lexical phonology and morphology (Kiparsky 1982), stratal OT (Bermúdez-Otero 1999, Kiparsky 2000, 2008, Bermúdez-Otero 2012), indexed constraint theory (Itô & Mester 1995, 1999, Fukazawa 1998, Prince & Smolensky 2004 [1993], Pater 2007, 2010), and cophonology theory (Orgun 1996, Inkelas et al. 1997, Anttila 2002, Inkelas & Zoll 2005, 2007). A distinct set of frameworks account for phonological alternations sensitive to syntactic or prosodic domain, those that cross word boundaries: match theory (Selkirk 2009, 2011, Elfner 2012, Ito & Mester 2013), contiguity theory (Richards 2016), and phase theory (Chomsky 2001, 2008, Newell & Piggott 2014). Recently, a number of proposals have set out to provide a unified analysis of domain-bounded and morpheme-specific phonology (Pak 2008, Booij 2010, Caballero & Inkelas 2013, McPherson 2014, Jenks & Rose 2015, McPherson & Heath 2016, Sande 2017, Kastner 2019).

I follow this line of recent work in arguing for a unified approach to morpheme-specific and syntactic-domain-bounded phonology. A single account of these phenomena is desirable, since the substance of the phonological alternations involved in lexically, morphologically, and syntactically conditioned phenomena appear to be the same. For example, §5 describes a vowel harmony process that applies across the board within a particular syn-

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tactic domain, and §6 describes a separate vowel harmony process that is sensitive to the identity of the morphemes present. The relevant domain in which harmony applies in both cases is coextensive with a syntactic phase boundary. In fact, phonological domains more broadly are found to align with syntactic phase boundaries. The current approach expands on previous work unifying morphologically conditioned and syntactically bounded phonology by making explicit the means by which morpheme- or construction-specific phonological effects are implemented in a modular grammar.

This article provides data from three distinct phonological alternations in Guébie (ISO: gie), an endangered Kru language spoken in Côte d'Ivoire: (i) scalar tone shift in imperfective contexts, which crosses word boundaries, (ii) ATR and nasal harmony within a particular sub-word syntactic domain, and (iii) lexically specific full vowel harmony. Each of these alternations is conditioned by a distinct set of extraphonological factors: a functional morpheme, lexical class, syntactic domain, or some combination of the three. I demonstrate that by adopting cophonologies by phase (Sande & Jenks 2018), a model that formally combines the phase-based spell-out of phase theory and the morpheme-specific phonological grammars of cophonology theory, we can account for sub-word and cross-word morpheme-specific phonological alternations in a unified way.

1.1. Conditioned phonological alternations. Numerous factors external to phonology can condition phonological alternations. For example, before some, but not all, *i*-initial suffixes in English, root-final /-k/ softens to [s] and /-g/ softens to [dʒ] (Chomsky & Halle 1968:219), as seen in 1.

(1) Morphologically conditioned velar softening in English (adapted from Halle 2005:36)

a.	electri[k]	electri[s]-ity
b.	opa[k]	opa[s]-ity
c.	analo[g]	analo[dʒ]-y
d.	esopha[g]-us	esopha[dʒ]-eal
e.	picni[k]	picni[k]-ing, *picni[s]-ing
f.	pani[k]	pani[k]-ing, *pani[s]-ing
g.	peaco[k]	peaco[k]-ish, *peaco[s]-ish
h.	boo[k]	boo[k]-ish, *boo[s]-ish

The suffixes in 1a–d condition velar softening on the roots they attach to, but the suffixes in 1e–h do not. One could imagine extending the /-ish/ suffix to an English word like *opaque*, which would result in *opa[k]-ish*, not **opa[s]-ish*. But the same root, *opaque*, does show velar softening before other morphemes like /-ity/ (1b). Only some high-vowel-initial suffixes condition velar softening in English. This sensitivity to the identity of the morphemes present is what I refer to as 'morphologically conditioned phonology'. We will see in §6 that the morpheme in question can be lexical or functional.

Inkelas (2014:Ch. 2.5) describes a number of additional examples of morphological construction-specific phonological alternations across languages, ranging from segment deletion in Turkish (p. 30) to tone reassignment in Hausa (p. 41). Each of the examples she discusses shows a productive phonological alternation that is limited to a particular morphosyntactic construction.

Morpheme-specific phonological alternations like these have been modeled in a variety of ways, where each framework makes a different set of predictions about the domain of application of morpheme-specific phonology. In lexical phonology and morphology (Kiparsky 1982), the grammar is split into strata, where irregular morphology falls into one or more lexical strata and regular morphology falls into the language-wide postlexical stratum. In this model, phonology applies at multiple points in a derivation: irregular, morpheme-specific rules like English velar softening apply in the lexicon, and across-the-board rules like English flapping occur postlexically. Evaluation of multiple words simultaneously does not occur until the postlexical stratum, and the postlexical stratum is exceptionless, predicting that morpheme-specific or exceptional phonology should apply only within a word or sub-word domain.

Certain constraint-based models have followed lexical phonology and morphology in incorporating lexical strata and morpheme-specific phonological operations into the grammar. One such constraint-based model is STRATAL OPTIMALITY THEORY (stratal OT; Bermúdez-Otero 1999, 2012, Kiparsky 2000, 2008). In traditional stratal OT, the phonology is split into stem, word, and phrasal levels of evaluation, where the ranking of constraints may differ from one level to the next. Morphemes that attach at the stem level are susceptible to the stem-level phonological grammar, while morphemes that attach later are not and are instead evaluated by a separate word-level grammar. In this way, morpheme-specific phonological alternations are derived. Similar to lexical phonology and morphology, multiple words are not evaluated together until the phrase level, which is the general, nonexceptional phonological level. Like lexical morphology and phonology, then, morpheme-specific phonology is expected to occur only within words at the stem or word level, and not across words.

An alternative to multiple-grammar models is single-grammar models (see Inkelas (2014), who introduces these terms), where a single set of rules or constraints determines the optimal phonological outputs across all constructions in a language. In such frameworks, in order to account for morpheme-specific effects, individual rules (Chomsky & Halle 1968, Lightner 1972) or constraints (Itô & Mester 1995, 1999, Fukazawa 1998, Prince & Smolensky 2004 [1993], Pater 2007, 2010, Jurgec & Bjorkman 2018) may be indexed to a specific morpheme or set of morphemes.

Constraints in single-grammar theories can be indexed to lexical categories or specific lexical or functional morphemes, resulting in phonological sensitivity to lexical and morphological information. However, in a single-grammar model, phonology applies globally to a word or phrase; accounting for the locality of a sub-word phonological process thus becomes a challenge. Additionally, indexation of constraints or rules requires the phonological grammar to make direct reference to morphosyntactic features and categories, a complication done away with in multiple-grammar theories such as stratal OT and cophonology theory (see especially Orgun 1996 and Inkelas & Zoll 2007).

These extant models predict that morpheme-specific effects should be limited to word or sub-word domains, summarized in 2. However, we will see in §4.1 that morpheme-specific effects can cross word boundaries, and in §5.1 that they can also be sensitive to a sub-word domain.

(2) Predictions of domain-boundedness of morpheme-specific phonology[1]

	sub-word-bounded	word-bounded	cross-word
Predicted	(X)	X	—
Actual	X	X	X

There is a discrepancy between the predicted domain of morpheme-specific phonological effects and the actual domain of phonological effects across languages. Traditionally,

[1] In indexed constraint theory, sub-word domains are not straightforwardly predicted to be the domain of phonological application, hence the parentheses.

frameworks developed to handle morphologically and lexically conditioned phonology, such as indexed constraint theory, lexical phonology and morphology, and stratal OT, have been invoked to model sub-word morpheme-specific processes, and they specifically predict that cross-word morpheme-specific effects should not exist. Cross-word phonological effects, by contrast, are often modeled in an entirely different set of frameworks, including phase theory (Chomsky 2001, 2008, Newell & Piggott 2014) and match theory (Selkirk 2009, 2011, Elfner 2012, Ito & Mester 2013). Here I show that cophonologies by phase (CBP) (Sande & Jenks 2018, Sande et al. 2019), a model of the morphophonology interface that relies on (i) application of morphological and phonological operations at syntactic phase boundaries and (ii) morpheme-specific constraint weights associated with lexical items, can account for sub-word, word-bounded, and cross-word morpheme-specific phonology in a unified way.

Traditional cophonology theory (Orgun 1996, Inkelas et al. 1997, Anttila 2002, Inkelas & Zoll 2005, 2007) also allows for morphological, syntactic, and lexical conditioning of phonology, based on construction. CBP as presented here builds on ideas of cophonology theory, integrating them with current assumptions of the architecture of the grammar and making more restrictive predictions than traditional cophonology theory does. Specifically, in CBP phonological evaluation applies at syntactic phase boundaries, sensitive to the morpheme-specific phonological requirements of elements introduced into the derivation during that phase.

Thus, phonology applies in parallel for all vocabulary items introduced within a single phase. This phase-delimited, construction-specific phonology restricts the domain within which morpheme-specific phonology can apply, making specific predictions about locality and scope of phonological effects, discussed in §2. Phases, rather than words, are the relevant domain of phonological evaluation. The apparent distinction between morpheme-specific word-bounded phonology and cross-word phonology is just that—apparent. The domain of application of both phenomena is restricted by syntactic phase boundaries, and both can be morpheme-specific.

The contributions of CBP include a formalization of construction-specific phonology and a clear view of how that formalization fits within the grammar as a whole. We will see that by associating lexical items with phonological constraint weights and cyclic phonological evaluation at syntactic phase boundaries, CBP straightforwardly accounts for morpheme-specific phonological alternations within and across word boundaries.

1.2. Article organization. Section 1.1 introduced the range of extraphonological conditioning factors that phonological processes may be sensitive to, as well as the predictions of frameworks that have been used to account for such conditioning factors. I next introduce CBP (§2), expanding on work in Jenks 2018, Sande & Jenks 2018, and Sande et al. 2019. Information on the Guébie language is provided in §3, which serves as necessary background for understanding the phenomena described in the next sections. Sections 4, 5, and 6 present the data for the three Guébie phenomena: morphologically conditioned scalar tone shift, syntactic-domain-specific ATR and nasal harmony, and a lexically and morphologically conditioned full vowel harmony process that requires two triggering morphemes to be present, showing that CBP can straightforwardly account for all three types of extraphonological conditioning. I discuss the implications of these conditioned phonological phenomena and compare their analyses in CBP to possible alternative accounts in §7, before concluding in §8.

2. Cophonologies by phase. This article adopts cophonologies by phase as a model of the morphology-phonology interface (Sande & Jenks 2018). CBP assumes a modular grammatical architecture, where morphology and phonology are interpreted from the hierarchical output of the syntax. Output forms are ultimately evaluated by a constraint-based phonological component. For the purposes of this article, I assume a morphological component as in DISTRIBUTED MORPHOLOGY, where vocabulary items are inserted late in the derivation and, specific to CBP, may be associated with a morpheme-specific constraint weighting, in addition to the traditional phonological feature content.

This section introduces the three key components of CBP: (i) phase-based spell-out (§2.1), (ii) enhanced vocabulary items (§2.2), and (iii) the mechanism by which morpheme-specific phonological constraint weights combine with the default grammar of a language to result in construction-specific phonological grammars (§2.3). These components interact to account for a wide range of interface phenomena, including phonological interaction across word boundaries (Sande & Jenks 2018, Sande et al. 2019), phonological alternations limited to sub-word domains (Jenks 2018 on Moro (Kordofanian)), and the syntactically, lexically, and morphologically conditioned processes discussed in §§4, 5, and 6.

2.1. SPELL-OUT BY PHASE. In CBP, crucially distinct from cophonology theory, its closest relative, the domain of application of morphological and phonological operations is the syntactic phase. Phases are syntactic constituents transferred to the morphological and phonological components of grammar during a process called SPELL-OUT (Chomsky 2000, 2001). The benefit of phase-based spell-out is that it makes specific predictions about locality and scope of both morphosyntactic and phonological effects. Much recent work outside of CBP also argues that morphological and phonological operations apply in phase-based chunks (Kratzer & Selkirk 2007, Pak 2008, Jenks & Rose 2015, Sande 2017, 2018a, Kastner 2019).

CBP assumes a universal set of syntactic phase heads, including Voice, C, and D (Chomsky 2000, 2001, Marvin 2002), as well as all category-defining heads such as *n*, *v*, and *a* (Arad 2003, Embick 2010). Note though that the case studies discussed here are consistent with the view that phase boundaries can vary with syntactic processes (Gallego 2007, Bošković 2014). Each phase head triggers spell-out, at which point phase heads and their complements undergo morphological operations, vocabulary insertion, and phonological evaluation (cf. Bošković 2016 on phase heads being spelled out with their complements). A toy example of phase-based spell-out is provided in §2.3.

Phases are held to the PHASE IMPENETRABILITY CONDITION (PIC). Once a phase is spelled out, the hierarchical structure inside the phase is no longer accessible to any component of grammar (cf. the SYNTACTIC PIC of Chomsky 2000:108). Phase boundaries limit the domain of syntactic operations (Chomsky 2012:5). CBP extends this view: the domain of morphological and phonological operations also aligns with phase boundaries. Unlike spelled-out syntactic material, however, previously spelled-out phonological material can be manipulated at later cycles of phonological evaluation, in later spell-out domains. This cyclic application of phonology at phase boundaries is necessary to derive opacity and domain-bounded effects.

The output of a spelled-out phase consists of an optimal phonological sequence. The internal morphosyntactic hierarchical structure of that phase is lost, and the spelled-out phase itself forms a single unit from the perspective of morphosyntax, which can be moved or copied as such. During subsequent rounds of spell-out, when phonology operates on hierarchically higher phases, lower, previously spelled-out phonological material is susceptible to further phonological manipulation. In this way, the model allows for cyclic morphophonological application and builds on previous frameworks allowing violable phonological faithfulness to previously spelled-out material (Kramer 2010, Shwayder 2015, McPherson & Heath 2016). This assumption differs from the modular PIC approach of D'Alessandro and Scheer (2015), who specify that language-specific parameters determine which spelled-out phonological material is fixed and cannot be manipulated at later instances of phonological evaluation.

Spell-out by phase erases the need to reference domains in the phonological component that are not referenced elsewhere by the grammar. For example, stratal OT (Bermúdez-Otero 1999, Kiparsky 2000, 2008) posits a sub-word stem level that does not necessarily correspond to a domain referred to by the syntactic or morphological components, but is specific to the phonology. Similarly, Cole and Kisseberth (1994) propose optimal domains theory (ODT), where a set of universal phonological domain boundaries may limit the scope of a phonological process. Like stratal OT, the phonological domains in ODT do not necessarily correspond to specific syntactic domains. In CBP, syntactic operations are sensitive to certain boundaries. Empirically, we find that these same boundaries, phase boundaries, tend to constrain the locality of phonological operations. Thus, in CBP, phase boundaries, which are already necessarily referred to in the syntactic component of the grammar, are analyzed as the domain of phonological evaluation. Positing a separate set of phonology-specific boundaries is unnecessary.

2.2. Enhanced vocabulary items. Where CBP crucially differs from other theories of the morphology-phonology interface is in the content of lexical items, called 'vocabulary items' in the terminology of distributed morphology. Following Sande & Jenks 2018, I assume that vocabulary items associate the morphosyntactic features present in the output of the syntax with three phonological components: (i) an underlying phonological representation $\mathcal{F}$, (ii) a prosodic subcategorization frame $\mathcal{P}$, and (iii) a reweighting specification for one or more phonological constraints $\mathcal{R}$. Whereas in traditional distributed morphology (Halle & Marantz 1993, 1994, Embick & Noyer 2001) vocabulary items map syntactic features to (supra)segmental phonological content, vocabulary items in CBP may also be associated with prosodic selection requirements and phonological constraint reweightings.

The underlying phonological representation $\mathcal{F}$ may consist of a segmental and/or suprasegmental representation. All $\mathcal{F}$ forms in this article are written as strings of segments with associated tones, though one could imagine this notation as shorthand for a set of distinctive features and tones associated via autosegmental representations (Goldsmith 1976).

Following recent work arguing that underlying forms consist of not only an underlying representation but also a prosodic selection specification (Inkelas 1990, Itô & Mester 2007, Paster 2009, Bennett et al. 2018), the second component, the prosodic subcategorization frame $\mathcal{P}$, specifies the selection requirements of the form in question. For example, $\mathcal{P}$ specifies whether the form $\mathcal{F}$ is a free-standing prosodic word, or whether it must attach to an element of a particular prosodic category. For bound morphemes, it also specifies the directionality of attachment: prefix versus suffix. The $\mathcal{P}$ specification of a given morpheme is a requirement on output forms. In CBP, only output candidates that satisfy all $\mathcal{P}$ specifications of morphemes in the evaluation domain are considered. Note, though, that these morpheme-specific requirements could be overwritten later, at future cycles of evaluation, since the $\mathcal{P}$ specification is active and available to the phonological component only during the phase in which a morpheme is initially spelled out. In other words, $\mathcal{P}$ is a method of mapping syntactic to prosodic structure, without requiring a separate step in the grammar of syntax-to-prosody mapping, as is assumed in match theory (Selkirk 2009, 2011).

In addition to prosodic structure building due to $\mathcal{P}$ specifications, prosodic structure is assumed to be built in one additional way in CBP: each phase domain is coextensive with a prosodic domain, as regulated by the MAXIMIZE PROSODIC DOMAINS constraint (3), introduced in Sande et al. 2019.

(3) MAXIMIZE PROSODIC DOMAINS: Phase-internal material is parsed into a single prosodic domain (e.g. word, prosodic phrase, intonational phrase).

I leave for future work the question of whether this constraint serves as a requirement on possible candidates, as the $\mathcal{P}$ specifications do, or as a violable constraint in the phonological grammar, since none of the case studies discussed here differentiate between these two options.

The third component, and the most crucial for the purposes of this article, is a weighting adjustment of phonological constraints $\mathcal{R}$. Note that in Sande & Jenks 2018 $\mathcal{R}$ consists of a phonological constraint reranking, rather than reweighting. Here I argue that reweighting makes better predictions than reranking. The addition of this third component is the key innovation of CBP. This morpheme-specific constraint reweighting builds on previous work in cophonology theory (Orgun 1996, Anttila 2002, Inkelas & Zoll 2005, 2007), making explicit the mechanism by which the phonological grammar can vary with morphological construction. Additionally, the mechanism of constraint-weighting adjustment, discussed further in §2.3, results in consistent weighting relationships between the majority of constraints throughout the entire grammar of a language—the default weights. Only in phases where at least one morpheme has a contentful $\mathcal{R}$ specification will certain constraints be reweighted. This restricted readjustment of the default grammar limits the possible variation we see across cophonologies in the same language.

Vocabulary items in CBP are written as extended versions of distributed morphology–style vocabulary items.

(4) CBP vocabulary item schema

$$[\text{Syntactic features}] \leftrightarrow \left\{\begin{array}{ll}\mathcal{F}\text{:} & \text{(Supra)segmental content}\\ \mathcal{P}\text{:} & \text{Prosodic subcategorization}\\ \mathcal{R}\text{:} & \text{Constraint reweighting: B}^{+2}\end{array}\right\}$$

Not every vocabulary item is associated with a constraint reweighting. In fact, for any vocabulary item, any of the three components in 4 may be null.[2] However, when a constraint reweighting $\mathcal{R}$ is present in the domain of phonological evaluation, it interacts with the default ranking of the language to result in a morphosyntactic construction-specific phonological grammar. Specifically, the weighting specifications associated with particular vocabulary items are mathematically added to the default weights of those constraints.

For example, given the default weight of constraint A as 2 and B as 1, and the abstract vocabulary item in 4 specified with the weighting B^{+2}, the resulting cophonology for the spell-out domain containing the vocabulary item in 4 will evaluate output candidates with the following weights: A = 2, B = 3. In this grammar, the weighting relationship of constraints A and B is reversed from what it is in the default grammar of the

[2] A null $\mathcal{F}$ corresponds to a lack of underlying phonological segments or suprasegmentals, as in process morphology; a null $\mathcal{P}$ could be found on any element where regular phonological constraints determine its prosodic position and structure. For example, the surface position of a 'mobile affix' (Jenks & Rose 2015) might be determined purely by phonological constraints. Similarly, an element that sometimes surfaces as a distinct prosodic word and elsewhere surfaces as an affix could lack a $\mathcal{P}$ specification. A null $\mathcal{R}$ means that there is no exceptional phonology associated with the presence of that particular morpheme.

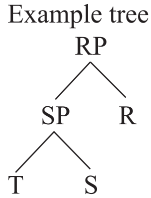
language, in that constraint B now has a higher weight than A. The combination of the default weight of B, 1, with the +2 readjustment specified in $\mathcal{R}$ results in a weight of 3 during this particular cycle of phonological evaluation. Constraints not specifically readjusted by $\mathcal{R}$ retain their default weights (as A does in this toy example), and spell-out domains in which no vocabulary item is associated with a reweighting are evaluated by the default grammar of the language. The interaction between morpheme-specific reweightings and default weights is elaborated on in §2.3.

This mapping of morphemes to phonological processes is similar in a way to construction morphology (Booij 2010, McPherson 2014); both construction morphology and CBP map syntactic information to phonological information: PHON ↔ SYN. However, constructions in construction morphology make direct reference to morphosyntax and are implemented as constraints in a separate step of the derivation, before the regular phonology of the language applies (e.g. X^L ADJ: Words c-commanded by an adjective take L tone; McPherson 2014). In CBP, phonology applies in a single step—morpheme-specific phonological requirements interact directly with the default phonological grammar of the language.

2.3. CONSTRAINT REWEIGHTING COMPOSITION AND INTERACTION. When no vocabulary item within a phase is specified with a constraint-reweighting $\mathcal{R}$, the default constraint weights of the language apply to the phonological material within that domain, similar to the MASTER RANKING of Anttila (2002). However, when one or more vocabulary items within a phase have a specified constraint reweighting, those weights interact with the default grammar to create a modified, construction-specific cophonology. In all cases, the default weightings are modified only as much as is specified by the $\mathcal{R}$s in the relevant domain. Only those constraints that are specified as reweighted by the morpheme-specific constraints are affected; all other subparts of the default system are unaffected. Specifically, I adopt the weighted constraint model of harmonic grammar (Legendre et al. 1990, Smolensky & Legendre 2006).[3]

In the syntactic tree in 5, R, S, and T are variables standing in for specific nodes in a syntactic structure. S is a phase head. When S is merged, it is spelled out together with its complement, T. The phase domain contains two terminal nodes, each of which is associated with a vocabulary entry, as in 6–7.

(5) Example tree



(6) Vocabulary entry for T

$$[T] \leftrightarrow \begin{Bmatrix} \mathcal{F}\text{:} & \text{bala} \\ \mathcal{P}_1\text{:} & [X_\omega] \\ \mathcal{R}_1\text{:} & \text{B}^{+2} \end{Bmatrix}$$

[3] A better model would be one that adopts maximum entropy harmonic grammar (Goldwater & Johnson 2003, Jäger 2007, Hayes & Wilson 2008) or noisy harmonic grammar (Boersma & Pater 2016), which output probability distributions over candidates. However, the majority of case studies discussed here are categorical, where a single output wins in all contexts. In the one variable case discussed in §6.1, the corpus of Guébie data is not yet large enough to compare frequencies of variable outputs with any certainty, so the goodness of fit of a maximum entropy or noisy harmonic grammar model cannot be computed. In future versions of CBP where the data in question is variable and relative frequencies of each output candidate are known, I expect one of these alternative weighted constraint models or the mixed-effects model of Zymet (2019) to be used.

(7) Vocabulary entry for S

$$[S] \leftrightarrow \left\{ \begin{array}{ll} \mathcal{F}: & \text{li} \\ \mathcal{P}_2: & \text{-}X]_{\omega} \\ \mathcal{R}_2: & \text{A}^{+4} \end{array} \right\}$$

In the $\mathcal{P}$ specification of the vocabulary entries above, X is a variable that represents the phonological content of the corresponding $\mathcal{F}$. The $\mathcal{P}_1$ of T in 6 specifies that the phonological content $\mathcal{F}$ is a prosodic word, ω. The $\mathcal{P}_2$ of S in 7 specifies that the phonological content of S is a suffix that forms a prosodic word together with the content it attaches to.

During the morphological component of the grammar, the vocabulary items above are inserted into the hierarchical structure in 5 during a process of vocabulary insertion (Embick & Noyer 2001, 2007, Pak 2008, Embick 2010). After vocabulary insertion, the vocabulary items in the hierarchical structure are composed as below, and the output of that composition, which contains only phonological information, is sent to the phonological component for evaluation. Throughout this article, the composition of vocabulary items and their subparts are notated with a set of superscripts. The superscripts contain indices to the prosodic specifications and constraint weights that phonological candidates are evaluated against in the relevant domain (Sande & Jenks 2018).

(8) S and T after vocabulary insertion and composition
/bala-li/$^{(\mathcal{P}^{1+2},\ \mathcal{R}^{1+2})}$

When the two vocabulary items in 6 and 7 are composed, they result in the sequence in 8, where the phonological content $\mathcal{F}$ of the domain is associated with a set of superscripts corresponding to the relevant prosodic requirements and constraint reweightings, $\mathcal{P}$ and $\mathcal{R}$, of that spell-out domain. The composed form in 8 is then the input to phonological constraint-based evaluation.

If the default constraint weights of the language are A = 2, B = 1, C = 3, then combined with the two reweightings $\mathcal{R}^{1+2}$, the minimally altered grammar used to evaluate this spell-out domain is A = 6, B = 3, C = 3 (A = 2 + 4 = 6; B = 1 + 2 = 3). Constraint weights unreferenced by $\mathcal{R}^{1+2}$ remain unchanged (the weight of C is still 3). Because the weights of A and B are promoted by $\mathcal{R}^{1+2}$, due to the specifications of the vocabulary items S and T, a new weighting relationship is present: in this domain only, A is more heavily weighted than C, a reversal from the weights specified in the default grammar.

Note that adding constraint weights, rather than adjusting constraint rankings, avoids the potential for conflicting constraint-ranking specifications within a spell-out domain (Sande et al. 2019). Instead, with weighted constraints, we can simply sum the total of the weights in the default grammar with the weights in the $\mathcal{R}$ specifications in the relevant domain (we will see both positive and negative constraint-weight readjustments throughout §§4–6). Multiple $\mathcal{R}$s may affect the same constraint, as we will see in §6.2. The use of weights rather than rankings is a crucial departure from Sande & Jenks 2018.

The phonologically optimal form is chosen based on the input in 8 and the constraint weights A = 6, B = 3, C = 3. Once chosen, this phonologically optimal form no longer contains information about internal hierarchical structure or morpheme boundaries, [$_{\omega}$ balali], and the cophonologies associated with that phase are lost. Later instances of spell-out are unaffected by the reweightings within lower phases. However, the output of each spell-out domain remains in the syntactic tree available to future cycles of evaluation. Previously spelled-out material is marked off in the compositional notation with brackets, as in 9.

(9) Composition of the S+T phase with the next highest phase
/[$_{\omega}$ balali]-o/$^{(\mathcal{P}^{3},\ \mathcal{R}^{3})}$

The $\mathcal{P}$ and $\mathcal{R}$ specifications of the T and S morphemes are no longer active; thus this second cycle of phonological evaluation, the T phase domain, is evaluated only against the $\mathcal{P}$ and $\mathcal{R}$ of the R morpheme. In this way, the higher R morpheme, introduced in a separate phase, is never subject to the cophonological requirements of T and S, introduced in a lower phase.

Via the composition operation, all reweightings within a single spell-out domain affect the phonological constraint weights that are used to evaluate and ultimately determine an optimal output for that domain. Phonology does not apply with the addition of each vocabulary item or morpheme, but at the phase boundary, simultaneously with all elements within the phase. In this way, morpheme-specific reweightings necessarily take scope over the phasal domain in which they are phonologically interpreted, but do not affect the phonological evaluation of material outside that domain. Sande and Jenks (2018) formalize this restriction as the PHASE CONTAINMENT PRINCIPLE, as given in 10.

(10) PHASE CONTAINMENT PRINCIPLE: Morphological operations conditioned internal to a phase cannot affect the phonology of phases that are not yet spelled out.

The prosodic subcategorization specifications $\mathcal{P}$ limit the possible output candidates; only outputs that satisfy $\mathcal{P}$ are considered during phonological evaluation. Phonological evaluation determines which of those possible candidates is optimal. It is conceivable that two morphemes within the same phase domain could have conflicting prosodic requirements; I propose that the grammar does not allow such derivations to succeed. The bulk of the discussion throughout the remainder of this article focuses on the interaction of morpheme-specific constraint weights, $\mathcal{R}$.

3. LANGUAGE BACKGROUND. Guébie is an endangered Kru language spoken in southwest Côte d'Ivoire by about 7,000 people. The data presented here was collected in collaboration with the Guébie community over the past five years, primarily in Gnagbodougnoa, Côte d'Ivoire. Each data point presented here is labeled with an index of the form SPK_YYYYMMDD (speaker_date), which corresponds to the bundle of audio files with the same name in the Guébie online database and archive (Bodji & Sande 2019) from which the example or set of examples was taken. All forms were confirmed by at least two native speakers.

As background for the phonological alternations presented in §§4, 5, and 6, the consonant, vowel, and tonal inventories of Guébie are provided in Tables 1–3 (Sande 2017).

	BILABIAL		LABIODENTAL		ALVEOPALATAL		PALATAL		VELAR		LABIOVELAR	
PLOSIVE	p	b			t	d	c	ɟ	k, kʷ	g, gʷ	kp	gb
NASAL		m				n		ɲ		ŋ, ŋʷ		
FRICATIVE			f	v	s							
APPROX.		ɓ				l		j				w

TABLE 1. Guébie consonant inventory.

With regard to the consonant inventory given in Table 1, the status of /v/ as a phoneme is questionable. It contrasts with similar segments, but only in a handful of lexical items, which may be borrowed from neighboring Kru languages. The implosive /ɓ/ is listed as an approximant because it patterns phonologically with /l, j, w/ and not with plosives. See Kaye 1981 for a discussion of similar patterns in other Kru languages.

The vowel inventory is provided in Table 2. There are ten contrastive vowels in Guébie, which can be differentiated by a set of four distinctive features, [high, back, round, ATR]. The ATR quality of suffix vowels alternates depending on the ATR qual-

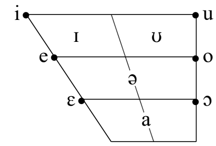


Table 2. Guébie vowel inventory.

ity of vowels in the root. This is analyzed as systematic root-conditioned ATR harmony within words and is discussed further in §5. +ATR vowels are [i, e, ə, u, o], while −ATR vowels are [ɪ, ɛ, a, ʊ, ɔ]. Schwa is the +ATR counterpart of /a/, which is clearly seen in its phonological behavior. A suffix /a/ will surface as [ə] following a root containing +ATR vowels, and within lexical items, [ə] cooccurs only with +ATR vowels (Sande 2017).

Guébie is a tonal language, with four distinct underlying tone heights (here labeled 1–4, where 4 is high). There are five distinct heights on the surface, 1–5, where 5 is a super-high tone that appears only in particular morphosyntactic contexts. These tone heights may surface as level tones or may combine to surface as contour tones on a single tone-bearing unit. There are a number of possible lexical tone melodies, provided in Table 3.

LEVEL TONES	FALLING TONES	RISING TONES
4	41	13
3	31	23
2	42	24
1	32	

Table 3. Guébie underlying tonal melodies.

We know that there are four marked tone heights, rather than, say, three marked heights plus a default tone, because all four heights are targets in contour tone sequences (Table 3) and because all four heights can spread, given the appropriate morphophonological conditions (Sande 2017). Thus, the grammar must be able to refer to all four distinct tone levels.

Missing from the list of lexical tone melodies are 21, 43, 12, 14, and 34. These contours or multilevel melodies are possible in derived contexts, such as the tone shift described in §4, but not on monomorphemic words. When multiple tone heights are associated with a single syllable, that syllable surfaces with a contour tone. Dots in tonal notation throughout represent syllable boundaries. Multiple tonal numbers written within a syllable represent a contour tone: for example, *na*^{24} or *nama*$^{2.31}$.

Underlyingly, syllables maximally contain a single onset consonant followed by a vowel, CV (we will see in §6.1 that some syllables can surface as CCV). Words tend to be monosyllabic: *li*^{3} 'eat', *no*^{4} 'mother'. Trisyllabic and larger words, particularly monomorphemic, are extremely rare. There are a few inflectional suffixes and a number of derivational affixes that can surface on nouns and verbs, but much of the morphology in Guébie is processual, involving phonological processes such as tone shift, tone replacement, vowel harmony, and vowel replacement.

In the next three sections I detail three phonological alternations in Guébie, each with distinct conditioning factors: (i) scalar tone shift in imperfective contexts, (ii) ATR and nasal harmony within a particular syntactic domain, and (iii) full vowel harmony on a subset of lexical items in the context of plural suffixes and object markers. A single unified analysis based in CBP is shown to account for the conditioning environments of all three processes.

4. Tone shift. This section serves to illustrate how the components of CBP interact to derive morpheme-specific phonological alternations that cross word boundaries. Data from a morphologically conditioned scalar tone shift is presented, and an analysis of the phenomenon is provided, couched in CBP. In Guébie, there is no segmental realization of the imperfective morpheme. However, in imperfective contexts there is a scalar tone shift that affects the surface tone of the verb and subject: the verb tone lowers one step on the four-tone scale, or the subject tone raises one step, depending on the context.

I take scalar shifts to be any phenomenon where in a particular context, elements shift one step in the same direction along an abstract phonological scale, resulting in a surface alternation. Chain shifts like the one presented here are a subtype of scalar shift (see Mortensen 2006 for a typology of phonological scalar shifts). Section 4.1 presents the facts, and §4.2 lays out an analysis in CBP.

4.1. Data. Tone is the sole exponent of imperfective aspect in Guébie. This tone shift is described in great detail in Sande 2017, 2018a. I recount the basics here, but see the prior work for additional tone-shift examples. Each lexical item is underlyingly specified for a given tonal melody. For verbs, this underlying melody surfaces faithfully in nearly every context in the language. This includes SAuxOV contexts, where the verb surfaces clause-finally when an auxiliary is present, imperative contexts where the verb surfaces clause-initially, and perfective SVO contexts where there is no auxiliary present. The verb 'eat', for example, has a lexically specified tonal melody of a level 3 tone, as in 11.[4]

(11) Underlying tone surfaces faithfully

a. SAuxOV

e^{4} ji^{3} ɟa^{31} **li^{3}**

1sg.nom fut coconuts eat

'I will eat coconuts.'

b. Imperative

li^{3}

eat.imp

'Eat!'

c. Perfective

e^{4} **li^{3}** ɟa-ɓe$^{3.1}$ kuɓə$^{3.1}$

1sg.nom eat.pfv coconuts-sg yesterday

'I ate a coconut yesterday.' (syl_20131024)

In imperfective contexts, however, the 'eat' verb, which surfaces immediately after the subject, surfaces with its tone one step lower on the four-tone scale than in its underlying form.

(12) Imperfective: tone surfaces one step lower

e^{4} **li^{2}** ɟa^{31} koko$^{4.4}$

1sg.nom eat.ipfv coconuts every.day

'I eat coconuts every day.' (syl_20131024)

This scalar tone shift in imperfective contexts results in tonal minimal pairs between the two SVO contexts, positive perfective and imperfective clauses, where the only difference between the two is the tone on the verb, as in 13.

[4] Abbreviations used throughout this article are as follows: 1/2/3: persons, acc: accusative, agt: agentive, caus: causative, fut: future, ipfv: imperfective, nmlz: nominalizer, nom: nominative, pass: passive, pfv: perfective, pl: plural, recip: reciprocal, sg: singular.

(13) Perfective/imperfective tonal minimal pairs
a. Perfective
e^{4} **li^{3}** ɟa^{31}
1SG.NOM eat.PFV coconuts
'I ate coconuts.'
b. Imperfective
e^{4} **li^{2}** ɟa^{31}
1SG.NOM eat.IPFV coconuts
'I eat coconuts.' (oli_20160801)

When the underlying tone of a verb involves more than one level tone, only the first tone level is affected by the imperfective tone shift. This is true both for polysyllabic verbs with a different level tone on each syllable and for contour tones, as shown in 14.

(14) Only the first tone level lowers
a. ju^{4} **gbala$^{3.4}$** si^{3}
boy climb.PFV trees
'A boy climbed trees.'
b. ju^{4} **gbala$^{2.4}$** si^{3}
boy climb.IPFV trees
'A boy climbs trees.'
c. ɔ^{3} **lu^{41}**
3SG.NOM carry.water.PFV
'She carried water (from the well).'
d. ɔ^{3} **lu^{31}**
3SG.NOM carry.water.IPFV
'She carries water.' (syl_20140314)

The recurring pattern is that the first tone level of a verbal tone melody surfaces one step lower in imperfective than other contexts. This is true whether the result is the initial verb tone becoming more different from the preceding subject tone (14a,b) or more similar to the preceding subject tone (14c,d); this shift can be classified as neither assimilation nor dissimilation. Instead, the consistent change triggered in imperfective contexts is a one-step shift along the four-tone scale.

(15) Verb tone lowering

Underlying tone	>>	Imperfective tone
4		3
3		2
2		1
1		1

When the underlying tone of a verb is low, it does not lower further to super-low in imperfective contexts. Instead, we see an alternation in subject tone: the final tone of the subject raises one step, as in 16.

(16) Subject tone raising
a. **ɛ^{3}** ɓɔ^{1}
3SG.NOM wither.PFV
'It withered.'
b. **ɛ^{4}** ɓɔ^{1}
3SG.NOM wither.IPFV
'It withers.'

c. **ɟaci^23.1^** pa^1^
Djatchi run.PFV
'Djatchi ran.'

d. **ɟaci^23.2^** pa^1^
Djatchi run.IPFV
'Djatchi runs.' (oli_20160801)

When the tone of the subject is high, tone 4, and surfaces before a low-toned verb in imperfective contexts, the verb cannot lower to a super-low; we never see surface super-low tones in the language. Instead, the subject tone raises to a super-high tone, tone level 5. This is the only environment in which we see a surface super-high tone in Guébie.

(17) a. **e^4^** pa^1^
1SG.NOM run.PFV
'I ran.'

b. **e^5^** pa^1^
1SG.NOM run.IPFV
'I run.' (syl_20140314)

The subject raising pattern before low-toned imperfective verbs is summarized in 18.

(18) Subject tone raising

Underlying tone	>>	Raised subject tone
4		5
3		4
2		3
1		2

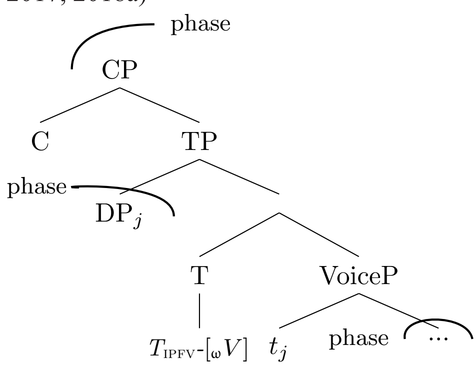
One possible analysis of the subject tone raising in imperfective contexts is that it does so to enhance tone lowering on the verb, in anticipation of the scalar downstepping of the following tone. However, this would predict that subject tones raise in all imperfective verb lowering contexts, which is not the case; subject tones raise in the imperfective only when the verb is lexically low. This is particularly clear when comparing an underlying /4 2/ tone sequence with an underlying /4 1/ sequence. In the former case, the verb tone lowers to [1], [4 1]. In the latter, the verb tone remains [1]. However, in the latter case only, the subject tone raises, [5 1]. If the subject tone systematically raised in anticipation, we would expect the subject to be super-high in both cases: [5 1], [5 1]. Instead, we see subject raising only when the verb is underlyingly low-toned.

The tonal shift described here affects the difference in tone height between the subject and verb only in imperfective contexts. The first tone height of a verb surfaces one step lower in the imperfective than elsewhere, unless the verb is already low, in which case the final subject tone raises one step in the imperfective. Worded differently, there is a greater pitch drop between the subject and verb from input to output in imperfective contexts than in other contexts. Crosslinguistically, we see many examples of tonal phenomena affecting multiple words within a phrase (Clements 1978, Zwicky, Kaisse, & Chen 1987, Downing 2003, Gussenhoven 2004, Selkirk 2011, Harry & Hyman 2014, Marlo et al. 2015, McPherson & Heath 2016). Some of these are across-the-board phonological effects, while others are morpheme-specific. Cross-word morpheme-specific alternations in particular are quite difficult to account for in a word-based model of phonological evaluation. I show in §4.2 that these effects are straightforwardly accounted for in CBP, where constraints evaluate entire syntactic phase domains simultaneously.

4.2. Analysis. The scalar tone shift in Guébie is conditioned by the imperfective morpheme, argued to be in the T position syntactically (Sande 2017). However, the phonological requirements of this morpheme-specific scalar shift also affect the phonological form of the subject (in the specifier position of T), which is part of a separate phonological word. This type of cross-word morpheme-specific effect is not predicted by other multiple-grammar frameworks such as stratal OT (Bermúdez-Otero 1999, Kiparsky 2000, 2008) and traditional cophonology theory (Orgun 1996, Anttila 2002, Inkelas & Zoll 2005, 2007), as discussed in §1.1. This section shows that CBP can easily account for cross-word morphologically conditioned phonological effects, as long as the effects are restricted to occurring within the same phase domain as the triggering morpheme. The syntactic structure for a regular Guébie main clause is provided below.

The entire CP is a phase, and phases below the clause level are demarcated with boundary lines in 19.

(19) Syntactic structure of a regular Guébie main clause (adapted from Sande 2017, 2018a)



D, Voice, and C are all phase heads. The structure below the VoiceP is a phase and is left out for the sake of simplicity. Upon being merged, phase heads are spelled out with their complements. The verb has moved up to T, where it creates a complex head with the imperfective morpheme, and it is evaluated again when the C phase head is merged. Vocabulary items are inserted and linearized. These linearized sequences are then interpreted by the phonological component.

The phonological constraints active during evaluation of a CP containing an imperfective morpheme must account for the fact that the tone of the verb lowers one step on the four-tone scale, unless is it underlyingly low, in which case the final tone of the subject raises one step. We can represent the imperfective tone shift formulaically, as in 20, where FST stands for final subject tone and IVT stands for initial verb tone. n represents some number, namely the difference between subject and verb tone in perfective contexts.

(20) Relationship between perfective and imperfective tone

Perfective	Imperfective
FST − IVT = n	FST − IVT = $n + 1$

It is not the case that subject and verb tone are always getting further apart from each other (cf. 14), but there is always more of a pitch drop in the imperfective than in the perfective, or input. Relevant constraints are modified from Sande 2017, 2018a to account for this shift.

(21) *0: Assign one violation for any output super-low tone.

(22) Ident-Tone (Id-Tone): Assign one violation for every step on the four-tone scale that an output tone differs from its corresponding input tone.

This IDENT-TONE constraint is evaluated in a scalar manner, where the closer a candidate's tone is to the input tone on the four-tone scale, the fewer violations it receives (cf. Kirchner 1997).

We also need a constraint to motivate the tone shift. I adopt here a modified version of PITCHDROP, originally introduced in Sande 2017, 2018a, which is a tonal antifaithfulness constraint.

(23) PITCHDROP (PIDROP): 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.

Input	Output
FST − IVT = n	FST − IVT = $n + 1$

This constraint motivates a tonal difference between input and output, much like previously proposed antifaithfulness constraints, such as HIGHER (Mortensen 2006), REALIZEMORPH (Kurisu 2001), and the series of antifaithfulness constraints proposed by Alderete (2001). Mortensen (2006) shows that scalar phenomena like the Guébie tone shift cannot be accounted for without the use of an antifaithfulness constraint.

The PITCHDROP constraint can be seen as motivated by the desire to demarcate edges of prosodic phrase boundaries. The object and verb are part of the same prosodic phrase, while there is a prosodic phrase boundary between the subject and verb, as in many other African languages (cf. Truckenbrodt 1999 on Kimatuumbi and Selkirk 2011 on Xitsonga). In general, prosodic phrases in Guébie are marked by a lack of vowel-hiatus resolution at their edges. That is, we see vowel hiatus on the surface only at prosodic phrase boundaries. The prosodic boundary between subject and verb is additionally marked with more of a pitch drop in the output than in the input.

The definition of the PITCHDROP constraint adopted here crucially differs from that proposed in Sande 2018a: there, PITCHDROP targeted the juncture between subject and verb, requiring the phonological component of the grammar to have access to syntactic category information such as the identity of the subject and verb. In this updated PITCHDROP constraint definition, we do away with the need for indexed constraints by referencing prosodic boundaries rather than syntactic categories.[5]

The final constraint needs to ensure that subjects are less likely than verbs to undergo a change from input to output. Here I adopt a positional faithfulness constraint, penalizing a lack of faithfulness at the right edge of a prosodic phrase. This negates the need for an indexed constraint like IDENT-NOUN, which references syntactic category. Note also that a constraint such as IDENT-PHASE, which specifies faithfulness to previously spelled-out phases (McPherson & Heath 2016), would not work in this case, because both the verb and the subject DP have been previously spelled out in lower phase domains. Instead, faithfulness to the right edge of a prosodic phrase results in verb lowering as the default operation, and subject raising only as a last resort.

(24) IDENT-TONE(Right, ϕ) (ID-TONE(R, ϕ)): 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.

[5] No other prosodic phrase boundary in Guébie is affected by this constraint. In complex imperfective clauses with more than two prosodic phrases, this constraint is not enough to prevent additional pitch drops. One could imagine getting around this problem by specifically referencing the boundary between subject and verb, which would require phonological reference to morphosyntax, or by referencing the leftmost prosodic phrase boundary in the domain, which for the C domain would always be the juncture between subject and imperfective verb.

In the default phonological grammar of Guébie, faithfulness is weighted as more important than antifaithfulness, and the markedness constraint *0 is particularly heavily weighted; we never see super-low tones in the language.[6]

(25) Default weights

Constraint	Weight
Ident-Tone	2
Ident-Tone(Right, ϕ)	2
*0	3
PitchDrop	1

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 Ident-Tone demoted by the morpheme-specific weights, $\mathcal{R}$.

(26) Imperfective vocabulary item

$$[\text{T, IPFV}] \leftrightarrow \left\{ \begin{array}{ll} \mathcal{F}\text{:} & \emptyset \\ \mathcal{P}_1\text{:} & [_\phi\, X\, [_\omega \ldots \\ \mathcal{R}_1\text{:} & \text{PitchDrop}^{+3}, \text{Id-Tone}^{-0.5} \end{array} \right\}$$

The prosodic requirements of the imperfective morpheme specify that upon composition, the left edge of a phonological phrase boundary, ϕ, is aligned to the left edge of the imperfective morpheme. Even though the featural content $\mathcal{F}$ of the vocabulary item is null, Ø, additional prosodic structure building occurs due to the $\mathcal{P}$ specification. The prosodic phrasing of subject separately from object and verb, (S)(VO), is internally motivated based on vowel hiatus and prosodic facts within Guébie and is also a crosslinguistically common prosodic phrasing strategy (cf. Elordieta et al. 2003 on Spanish and Catalan, Selkirk & Tateishi 1991 on Japanese, and Zwicky, Kaisse, 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 4, and Ident-Tone from 2 to 1.5, resulting in a weighting reversal between PitchDrop and Ident-Tone from default to imperfective contexts.

The imperfective vocabulary item in 26 composes with the previously spelled-out subject pronoun $[_\phi\, [_\omega\, \text{e}^4]]$ and verb root $[_\omega\, \text{li}^3]$ to result in the phonological input in 27. The positional faithfulness constraint Ident-Tone(Right, ϕ) ensures that the tone of any material to the right of the verb inside the second phonological phrase (S)(VO) does not undergo a change. The default means of satisfying the PitchDrop constraint will be to manipulate the tone of the left edge of the second prosodic phrase, the tone of the inflected verb, rather than to manipulate the right edge of the first prosodic domain, which is sensitive to Ident-Tone(Right, ϕ).

The phonological evaluation of the imperfective clause *e*^{4} *li*^{2} *ɟa*^{31} 'I eat coconuts' is shown below. The weights associated with the imperfective T head add to the master constraint weights, increasing the weight of PitchDrop. This results in verb tone lowering only in clauses with an imperfective T head.

[6] The weights adopted here are not the only set of weights that work for this phenomenon. See n. 3 for a solution in alternative weighted constraint models where weights would be determined by best match to the probability distribution of output candidates.

(27) Output of phonological composition of the Guébie CP
/[[$_\phi$ [$_\omega$ e^4]] [$_\omega$ li^3] [$_\omega$ ɟa^{31}]]/$^{(\mathcal{R}^1,\ \mathcal{P}^1)}$

(28) Phonological evaluation of the Guébie CP

/[$_\phi$ [$_\omega$ e^4]] [$_\phi$ [$_\omega$ li^3] [$_\omega$ ɟa^{31}]]/	*0 3	PIDROP 4	ID-TONE(R, ϕ) 2	ID-TONE 1.5	*H*
a. [[$_\phi$ [$_\omega$ e^4]] [$_\phi$ [$_\omega$ li^3][$_\omega$ ɟa^{31}]]]		1			4
b. ☞ [[$_\phi$ [$_\omega$ e^4]] [$_\phi$ [$_\omega$ li^2][$_\omega$ ɟa^{31}]]]				1	1.5
c. [[$_\phi$ [$_\omega$ e^5]] [$_\phi$ [$_\omega$ li^3][$_\omega$ ɟa^{31}]]]			1	1	3.5
d. [[$_\phi$ [$_\omega$ e^4]] [$_\phi$ [$_\omega$ li^1][$_\omega$ ɟa^{31}]]]				2	3

Note that the subject and object DPs, and the verb, have independently been previously spelled out, and thus at the CP stage of the derivation are simply linear sequences of phonological content. In the weighted constraint model adopted here, the candidate with the lowest harmony score, here candidate 28b, is judged to be optimal. The difference between the prosodic structure in the composed form in 27 and the input to the tableaux in 28 is that the form in 28 has been made compatible with the prosodic specification of the imperfective morpheme, which states that the imperfective morpheme is at the left edge of a prosodic phrase that dominates at least the next prosodic word to the right, the verb. All output candidates considered are faithful to this prosodic input specification.

Additionally, the entire clause, SVO, forms a single prosodic unit, presumably an intonational phrase. The outer brackets around each candidate represent the maximal prosodic domain that contains all of the phonological content of that spell-out domain. The construction of this prosodic unit is ensured by the constraint MAXIMIZE PROSODIC DOMAINS, as defined in 3 above, which specifies that phase-internal material should be parsed into a single prosodic domain. The label associated with that prosodic domain is determined by other constraints in the language (*RECURSION, etc.), not discussed further here.

In cases where the verb has an input low tone, 1, we do not see the verb tone lowering to 0. Rather, we see PITCHDROP satisfied via subject tone raising, as with *e*^{5} *pa*^{1} 'I run' (see 17 above). This is captured by the highly weighted *0 constraint.

(29) Phonological evaluation of the Guébie CP with low-toned verb

/[$_\phi$ [$_\omega$ e^4]] [$_\phi$ [$_\omega$ pa^1]]/	*0 3	PIDROP 4	ID-TONE(R, ϕ) 2	ID-TONE 1.5	*H*
a. [[$_\phi$ [$_\omega$ e^4]] [$_\phi$ [$_\omega$ pa^1]]]		1			4
b. [[$_\phi$ [$_\omega$ e^4]] [$_\phi$ [$_\omega$ pa^0]]]	1			1	4.5
c. ☞ [[$_\phi$ [$_\omega$ e^5]] [$_\phi$ [$_\omega$ pa^1]]]			1	1.5	3.5

Subject raising is ruled out as the default way to satisfy PITCHDROP by the IDENT-TONE(Right, ϕ) constraint, which penalizes nonfaithfulness to the right edge of a prosodic word (cf. 28c). The result is that verb tone lowering is the default strategy for satisfying PITCHDROP. The subject will raise to satisfy PITCHDROP only if there is some interfering markedness constraint, in this case *0, that prevents verb tone lowering, as in 29b,c.

In other tense-aspect-mood contexts, the $\mathcal{R}$ specification of the T head is empty, so the default constraint weighting of the language applies, as in 30.

(30) Composition of CP containing subject and perfective verb
/[$_\phi$ [$_\omega$ e^4]] [$_\omega$ li^3]/$^{(\mathcal{R}_{pfv},\ \mathcal{P}_{pfv})}$

(31) Phonological evaluation of perfective CP: Faithful output

/[$_\phi$ [$_\omega$ e^4]] [$_\phi$ [$_\omega$ li^3]]/	*0 3	PIDROP 1	ID-TONE(R, ϕ) 2	ID-TONE 2	*H*
a. ☞ [$_\phi$ [$_\omega$ e^4]] [$_\phi$ [$_\omega$ li^3]]		1			1
b. [$_\phi$ [$_\omega$ e^4]] [$_\phi$ [$_\omega$ li^2]]				1	2
c. [$_\phi$ [$_\omega$ e^4]] [$_\phi$ [$_\omega$ li^1]]				2	4
d. [$_\phi$ [$_\omega$ e^5]] [$_\phi$ [$_\omega$ li^3]]			1	1	4
e. [$_\phi$ [$_\omega$ e^3]] [$_\phi$ [$_\omega$ li^3]]		1	1	1	5

The composition of the subject and perfective verb in 30 is evaluated against the default grammar, because the reweighting $\mathcal{R}$ of the perfective vocabulary item contains only the empty set, which has no effect on the overall constraint-based grammar. Thus, the CP spell-out domain containing the perfective morpheme is subject to the default grammar, in which the faithful candidate will always surface as optimal. The two cophonologies shown here involve the same subset of constraints, weighted differently based on the morpheme-specific weights introduced during each phase. The different grammars result in tonal minimal pairs between perfective and imperfective contexts, as in 13.

Guébie scalar tone shift is a morpheme-specific phenomenon that affects more than one word simultaneously. Previous word-based approaches like lexical morphology and phonology and stratal OT, discussed in §1.1, do not predict cross-word morpheme-specific phenomena like this to exist. Crucially, because CBP evaluates phases rather than words, this kind of cross-word morpheme-specific effect is predicted as long as it is limited to the phase domain within which the trigger morpheme was introduced.

5. ATR AND NASAL HARMONY. This section presents data from a second set of conditioned phonological alternations in Guébie: root-controlled ATR and nasal harmony within a sub-word domain. ATR harmony in Guébie is controlled by features of the root and applies only to a subset of suffixes. All of the suffixes that are harmony undergoers are linearly and hierarchically closer to the root than those that do not undergo harmony. Those that do not undergo harmony include a series of three nominalizing suffixes, a polar question marker, and object-marking enclitics. I analyze this split among suffixes as due to an intervening syntactic phase boundary. Everything within the syntactic domain of the Voice head undergoes harmony, while elements outside that domain do not. Section 5.1 presents the facts, and §5.2 shows how the phase-based evaluation of CBP accounts for sensitivity to syntactic domain.

5.1. DATA. There are a number of verbal suffixes in Guébie, including valency-changing and nominalizing morphemes. Verbal suffixes and their relative positions are provided in the verbal template in 32 (Sande 2017).

(32) Verbal morphology template

$$\textit{Root} - \begin{bmatrix}\textbf{Caus}\\ \textbf{Pass}\end{bmatrix} - \textbf{Appl} - \textbf{Recip} - \begin{bmatrix}\text{Nmlz1}\\ \text{Nmlz2}\\ \text{Agt}\\ \text{Obj} - \text{PolarQ}\end{bmatrix}$$

There is not enough data to say whether the causative morpheme systematically precedes passive, or vice versa. Additionally, any given verb can surface with only one nominalizing morpheme. For some speakers, verbs cannot be nominalized with an overt object-marking enclitic attached, and polar question markers surface only on non-nominalized verbs.

A subset of verbal affixes show ATR harmony with roots. Specifically, valency-changing suffixes (in bold above) show ATR alternations depending on the root they attach to. For some verbs, a verbal particle can surface as a prefix. The particle participates in harmony (Sande 2017:Ch. 2) and follows the same pattern as the valency-changing (harmony) suffixes discussed in this section. However, little is known about the syntax of particle verbs in Guébie, so I leave them out of the current discussion. The two event nominalization suffixes, the agentive suffix, object pronoun enclitics, and the polar question-marking enclitic, by contrast, do not undergo harmony. All elements that fail to show harmony appear outside of, linearly to the right of, the morphology that does undergo ATR harmony.

Roots that contain +ATR vowels, [i, e, u, o, ə], cooccur with the +ATR variants of valency-changing affixes, while roots that contain −ATR vowels, [ɪ, ɛ, ʊ, ɔ, a], cooccur with −ATR vowels in valency-changing affixes. The multiple surface forms of each valency-changing morpheme are provided in 33. ‘Red’ stands for reduplication of the verb root, such that in reciprocal contexts we see two copies of the verb root, followed by /-li^{2}/.

(33) Surface allomorphs of valency-changing suffixes

	+ATR	−ATR
Causative	-ə^{2}	-a^{2}
Passive	-o^{2}	-ɔ^{2}
Applicative	-li^{2}	-lɪ^{2}
Reciprocal	-red^{2}-li^{2}	-red^{2}-lɪ^{2}

Within the same domain in which root-conditioned ATR harmony applies, as in 32, we also see nasal harmony across sonorant consonants. Sonorant consonants in suffixes surface as nasal after a nasal consonant in the root, [m, n, ɲ, ŋ], and as nonnasal after nonnasal consonants in the root. Just as with ATR harmony, nasal harmony fails to apply to the nominalizing suffixes. Causative and passive suffixes are vacuously affected by nasal consonant harmony, since they do not contain any consonants. However, the /l/ of the applicative and reciprocal surfaces as [n] when following a nasal in the root.

Examples of root-conditioned harmony on causative and applicative suffixes are given in 34. For the sake of space I leave out passive and reciprocal suffixes, which show harmony in the same environments as the causatives and applicatives. +ATR suffix vowels follow +ATR roots (34a–e), −ATR suffix vowels follow −ATR roots (34f–j), and nasal suffix consonants follow nasal consonants in roots (34k–m).

(34) Harmony with causative and applicative suffixes

	root	root+caus	root+appl	root gloss
a.	li^{3}	li-ə$^{3.2}$	li-li$^{3.2}$	‘eat’
b.	sedi$^{3.1}$	sedi-ə$^{3.1.2}$	sedi-li$^{3.1.2}$	‘marry’
c.	bulu$^{2.2}$	bulu-ə$^{2.2.2}$	bulu-li$^{2.2.2}$	‘fly’
d.	sijo$^{2.3}$	sijo-ə$^{2.3.2}$	sijo-li$^{2.3.2}$	‘wipe’
e.	gugʷə$^{2.3}$	gugʷə-ə$^{2.3.2}$	gugʷə-li$^{2.3.2}$	‘remember’
f.	sɪ^{2}	sɪ-a$^{2.2}$	sɪ-lɪ$^{2.2}$	‘tire’
g.	ɲɛpɛ$^{3.1}$	ɲɛpɛ-a$^{3.1.2}$	ɲɛpɛ-lɪ$^{3.1.2}$	‘sweep’
h.	ɟʊla$^{3.2}$	ɟʊla-a$^{3.2.2}$	ɟʊla-lɪ$^{3.2.2}$	‘take/borrow’
i.	kɔlɔ$^{2.2}$	kɔlɔ-a$^{2.2.2}$	kɔlɔ-lɪ$^{2.2.2}$	‘stay’
j.	pa^{1}	pa-a$^{1.2}$	pa-lɪ$^{1.2}$	‘run’

k.	ni^{4}	ni-ə$^{4.2}$	ni-ni$^{4.2}$	‘see’
l.	ɲɛ^{3}	ɲɛ-a$^{3.2}$	ɲɛ-nɪ$^{3.2}$	‘give’
m.	mana$^{2.2}$	mana-a$^{2.2.2}$	mana-nɪ$^{2.2.2}$	‘drink’

Note that the intervening obstruent [p] in 34g blocks the spreading of the [+nasal] feature of the /ɲ/ in /ɲɛpɛ$^{3.1}$/ to the suffix. Only sonorants are subject to nasal agreement; obstruents block and fail to participate in harmony.

The outer morphemes (in 35), unlike the valency-changing affixes, have only one surface form each and do not alternate with the root.

(35) Surface allomorphs of outer suffixes

Nmlz1	-li^{2}
Nmlz2	-ɛ^{2}
Agt	-ɲɔ^{2}
PolarQ	-sɛ^{4}
Obj	=ɔ^{2}

The third-person human object enclitic in 35 is meant to stand in for the full series of object enclitics, which always surface with their default ATR value. Object markers are discussed further in §6, so I leave them out of the remainder of the data presentation here.

Unlike the valency-changing suffixes, outer suffixes do not alternate with ATR or nasal values of root segments. The event nominalizer /-li^{2}/ is used in the following examples to represent the outer suffixes and is given in boldface in the following.

(36) No harmony with nominalizing suffixes

	root	root+nmlz	root+caus+appl+nmlz	root gloss
a.	li^{3}	li-**li**$^{3.2}$	li-ə-li-**li**$^{3.2.2.2}$	‘eat’
b.	bulu$^{2.2}$	bulu-**li**$^{2.2.2}$	bulu-ə-li-**li**$^{2.2.2.2.2}$	‘fly’
c.	gugʷə$^{2.3}$	gugʷə-**li**$^{2.3.2}$	gugʷə-ə-li-**li**$^{2.3.2.2.2}$	‘remember’
d.	pa^{1}	pa-**li**$^{1.2}$	pa-a-lɪ-**li**$^{1.2.2.2}$	‘run’
e.	kɔlɔ$^{2.2}$	kɔlɔ-**li**$^{2.2.2}$	kɔlɔ-a-lɪ-**li**$^{2.2.2.2.2}$	‘stay’
f.	ni^{4}	ni-**li**$^{4.2}$	ni-ə-ni-**li**$^{4.2.2.2}$	‘see’
g.	ɲɛ^{3}	ɲɛ-**li**$^{3.2}$	ɲɛ-a-nɪ-**li**$^{3.2.2.2}$	‘give’
h.	mana$^{2.2}$	mana-**li**$^{2.2.2}$	mana-a-nɪ-**li**$^{2.2.2.2.2}$	‘drink’

Outer affixes are never affected by harmony. The four surface allomorphs of the applicative and the single surface form of an event nominalizer are given in 37. Note that when following a root with +ATR vowels and −nasal consonants, their forms are identical. However, when the root contains −ATR vowels or +nasal consonants, the applicative alternates while the nominalizer does not.

(37) Surface allomorphs of applicative and nominalizer

	+ATR, +nasal	+ATR, −nasal	−ATR, +nasal	−ATR, −nasal
Appl	li^{2}	ni^{2}	lɪ^{2}	nɪ^{2}
Nmlz	li^{2}	li^{2}	li^{2}	li^{2}

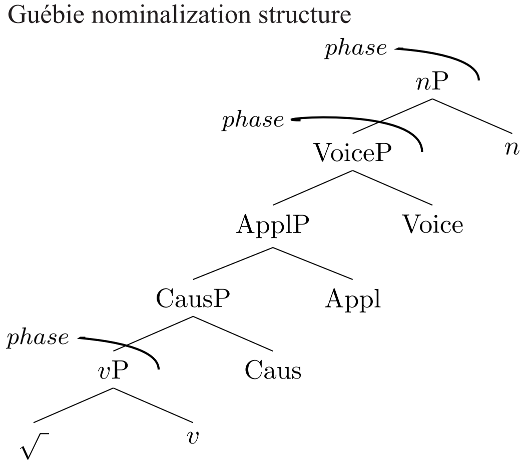
The following section presents a CBP account of the Guébie data, deriving the domain-based ATR and nasal harmony in Guébie without also incorrectly predicting that outer suffixes such as /-li^{2}/ should undergo ATR and nasal harmony.

5.2. Analysis. The fact that valency-changing suffixes show ATR and nasal alternations while outer morphemes do not could be analyzed in a number of ways. In a cyclic, rule-based analysis, left-to-right ATR and nasal harmony could apply as each suffix is attached. Then the outer morphemes, which do not undergo harmony, could be specified as such in the lexicon or via indexed rules (Chomsky & Halle 1968). This approach would not account for particle verbs, which surface to the left of the root but still undergo harmony. A constraint-based account in a single-grammar model such as indexed constraint theory would need to specify a list of suffixes that do not undergo harmony with a set of morphologically indexed constraints. For example, a set of constraints such as IDENT-NMLZ1, IDENT-NMLZ2, IDENT-AGT, and so forth, would outrank the constraints motivating ATR and nasal harmony. However, this indexed constraint analysis misses the generalization that all of the harmony-undergoing morphemes are linearly and hierarchically closer to the verb than the nonundergoers are.

I analyze the domain of ATR and nasal harmony across verbal affixes as due to a significant syntactic boundary between the valency-changing morphemes and the nominalizing suffix. The set of morphemes that undergo ATR and nasal harmony are all introduced within the same phase as the Voice head, which is associated with a constraint weighting where harmony-motivating constraints overpower identity constraints. The outer morphemes, introduced in a later phase and thus in a later spell-out domain, are no longer subject to the morpheme-specific effects of the Voice head.

Throughout this analysis section, rather than showing the derivation for every possible verbal affix, I use two valency-changing affixes, causative and applicative, to represent the harmony-undergoing class, and one outer morpheme, the event nominalizer /-li^2/, to represent the nonundergoing class. The proposed clause structure for a causative- and applicative-marked nominalized verb is given in 38 (see, for example, Pylkkanen 2000 on arguing for a structure where Voice appears above a separate Causative head).

(38) Guébie nominalization structure



In the tree above, *v*, Voice, and *n* are phase heads. When the verbalizing head *v* is merged, it is spelled out together with its complement, in this case the root. When the Voice head is merged, it is spelled out together with its complement, which contains valency-changing morphology, and the previously spelled-out verb root. This Voice-headed phase is the domain of ATR and nasal harmony. Anything outside of this domain will not be subject to the Voice-associated cophonology that motivates harmony.

The constraints relevant in accounting for the distribution of nasal and ATR harmony are defined below.

(39) IDENT-IO(ATR) (ID(ENT)-ATR; McCarthy & Prince 1995): Assign one violation if an output segment differs in ATR value from the corresponding input segment.

(40) IDENT-IO(Nasal) (ID(ENT)-NAS; McCarthy & Prince 1995): Assign one violation if an output segment differs in nasal value from the corresponding input segment.

(41) $*[\alpha\text{ATR}][\beta\text{ATR}]_{[+\text{syllabic}]}$ (ATRHarm(ony)): A segment with some value of the feature [ATR] may not directly precede another segment with a different ATR feature value in the ordered set of output segments that are [+syllabic] (i.e. vowels). Assign one violation for each output form where at least one pair of vowels meets these criteria.

(42) $*[\alpha\text{NASAL}][\beta\text{NASAL}]_{[+\text{sonorant, +consonantal}]}$ (Nas(al)Harm(ony)): A segment with some value of the feature [nasal] may not directly precede another segment with a different [nasal] feature value in the ordered set of output segments that are [+sonorant, +consonantal]. Assign one violation for each output form where at least one pair of sonorant consonants meets these criteria.

I use agreement-by-projection (ABP) constraints (proposed by Hansson (2014), and illustrated in Walker 2016 and Lionnet 2016, 2017) to account for ATR and nasal harmony. ABP constraints conflate the work of the agreement-by-correspondence (ABC) constraints Corr and CC-Ident[F] (Hansson 2001, Rose & Walker 2004) into a single constraint by evaluating only those segments with a particular feature (here [+syllabic] for ATR harmony and [+sonorant, +consonantal] for nasal harmony), on a separate tier from the rest of the word or phrase under evaluation.

While vowels are partially nasalized following nasal consonants in Guébie (Sande 2017:Ch. 2), they are not analyzed here as undergoing or triggering nasal harmony. There is no phonological effect of vowel nasalization, and there are no contrastive nasal vowels in the language. Instead, only sonorant consonants trigger and undergo nasal harmony, as specified in the ABP NasalHarmony constraint in 42.

The constraints here are evaluated wholesale, rather than gradiently. The default constraint weights are provided in 43.

(43) Default constraint weights for harmony

Constraint	Weight
Ident-ATR	3
Ident-Nas	3
ATRHarm	1
NasHarm	1

The high weight of the Ident constraints and the comparatively low weight of the Harmony constraints will always result in a faithful optimal output and a lack of harmony when the default grammar applies. Only in the case of a morpheme-specific reweighting of at least one of these two constraints will we see harmony.

The data in §5.1 showed that ATR and nasal harmony always hold within the domain of the extended projection of the verb and do not apply outside that domain. Thus, I posit that there is a phonological constraint reweighting associated with the vocabulary item of the Voice head, given in 44, which promotes the ABP constraints motivating harmony and demotes faithfulness.

(44) Vocabulary item for Voice

$$[\textit{Voice}] \leftrightarrow \left\{ \begin{array}{ll} \mathcal{F}: & \emptyset \\ \mathcal{P}_3: & \emptyset \\ \mathcal{R}_3: & \text{ATRHarm}^{+2}, \text{NasHarm}^{+2}, \text{Id-ATR}^{-2}, \text{Id-Nas}^{-2} \end{array} \right\}$$

When the *v* is merged, it is spelled out with its complement, the verb root. The *v* head has no $\mathcal{R}$ specification, so the default grammar applies. In the higher Voice phase, the subweights associated with all valency-changing morphemes (Ø) and the Voice head (in 44) combine with the weights of the default grammar: ATRHarm, NasalHarm = 3; Ident-ATR, Ident-Nasal = 1.

The weights determined by the Voice vocabulary item result in ATR and nasal harmony only within the spell-out domain containing the Voice head, as shown in the composition and phonological evaluation of *ɲɛ-a-nɪ*$^{3.2.2}$ 'give+CAUS+APPL' (cf. 34l) in 45–46.

(45) Composition of verb plus valency-changing suffixes
/[$_ω$ ɲɛ^3]-ə^2-li^2/$^{(\mathcal{P}^3,\ \mathcal{R}^3)}$

(46) Verbal domain (Verb + Caus + Appl): Harmony

/[$_ω$ ɲɛ^3]-ə^2-li^2/	ATRHARM 3	NASALHARM 3	ID-ATR 1	ID-NAS 1	*H*
a. [$_ω$ ɲɛ^3-ə^2-li^2]	1	1			6
b. [$_ω$ ɲɛ^3-ə^2-ni^2]	1			1	4
c. [$_ω$ ɲɛ^3-a^2-lɪ^2]		1	1		4
d. ☞ [$_ω$ ɲɛ^3-a^2-nɪ^2]			1	1	2

Only candidates that satisfy the $\mathcal{P}$ specifications of all morphemes introduced in the phase being evaluated are considered.

Note that the decision to represent the underlying phonological content $\mathcal{F}$ of the valency-changing suffixes as containing +ATR vowels is arbitrary. These suffixes could have −ATR vowels or vowels unspecified for ATR quality, and the result of the tableau in 46 would not change. The best analysis of the underlying features of these affix vowels may be that they are underspecified for ATR value, which would also account for the directionality of the harmony as determined by the underlying value of the root vowel rather than the affix vowel; however, for the sake of simplifying the amount of notation introduced here, I write these input vowels as +ATR.

The nominalizer /-li^2/ is itself the phonological realization of an *n* head. It is not spelled out in the same domain as Voice, but in the next highest phasal domain. By the time the *n* is spelled out, the subweights associated with Voice are no longer active, and the *n* head itself is not associated with any constraint readjustments, so the default grammar applies. Thus, the nominalizing suffix is not subject to the cophonology where harmony outweighs faithfulness. Instead, the faithful output is optimal.

(47) Vocabulary item for *n*

$$[n] \leftrightarrow \left\{ \begin{array}{ll} \mathcal{F}: & \text{li}^2 \\ \mathcal{P}_4: & [_{\omega}\ \text{-}X] \\ \mathcal{R}_4: & \emptyset \end{array} \right\}$$

Composition of the nominalizer with the output of the previous cycle is shown in 48 and evaluation in 49 (cf. 36).

(48) Composition of verb and valency-changing suffixes plus nominalizer
/[$_ω$ ɲɛanɪ$^{3.2.2}$]-li^2/$^{(\mathcal{P}^4,\ \mathcal{R}^4)}$

(49) Default (Verb stem + Nmlz): No harmony

/[$_ω$ ɲɛanɪ$^{3.2.2}$]-li^2/	ID-NAS 3	ID-ATR 3	NASALHARM 1	ATRHARM 1	*H*
a. ☞ [$_ω$ ɲɛanɪ$^{3.2.2}$-li^2]			1	1	2
b. [$_ω$ ɲɛanɪ$^{3.2.2}$-lɪ^2]		1	1		4
c. [$_ω$ ɲɛanɪ$^{3.2.2}$-ni^2]	1			1	4
d. [$_ω$ ɲɛanɪ$^{3.2.2}$-nɪ^2]	1	1			6

Within the phase containing the Voice head, ATR and nasal harmony apply. In the default grammar, IDENT constraints outweigh harmony constraints, resulting in ATR and nasal features surfacing faithfully to their underlying values. The result is ATR and nasal harmony within the syntactic domain of the extended verbal projection, but not outside of the phase containing the Voice head.

In a global constraint-based model such as parallel OT (Prince & Smolensky 2004 [1993]) or in a single-grammar version of harmonic grammar, when harmony is motivated, we expect it to apply across the board, affecting nominalizing suffixes just as it affects valency-changing morphology. Instead, applying morphological and phonological evaluation at each syntactic phase boundary predicts phonological effects sensitive to the syntactic domain. Alternative multiple-grammar theories such as stratal OT (Bermúdez-Otero 1999, Kiparsky 2000, 2008) could also be used to model the Guébie ATR and nasal harmony facts; in fact, this pattern is directly accounted for by the strong domain hypothesis of Kiparsky (1984). However, as discussed in §2, stratal OT requires reference to phonology-specific domains of evaluation, whereas CBP reuses phase boundaries, already needed in other components of the grammar. Additionally, stratal OT cannot as straightforwardly account for the other phenomena discussed here, including the tone shift in §4.

One possible alternative would be to say that phonology is evaluated at each instance of syntactic merge, in which case each valency-changing suffix would be associated with its own subweight, resulting in harmony for that particular morpheme. However, this alternative misses the generalization that every morpheme within the Voice phase, and none outside of it, undergoes harmony. If phonological evaluation applied at each instance of merge, it would be a coincidence that every valency-changing morpheme undergoes ATR and nasal harmony with the verb, while outer morphemes such as nominalizers do not.

Evaluation by phase captures the domain-specific effects of this harmony straightforwardly. Thus far we have seen how CBP can account for morphologically conditioned phonology across words and within a sub-word domain. What these phenomena have in common is that they apply within a phase.

6. Full vowel harmony. This section discusses a third conditioned phonological phenomenon in Guébie: full vowel harmony, or vowel replacement. This particular alternation stands as distinct from the previous two in that it requires two extraphonological triggers: it is conditioned by a particular subset of suffixes and enclitics, and it applies only to a subset of lexical roots. Both a specific functional morpheme and lexical item of a particular class must be present in the same phase domain for the vowel-replacement process to apply.

Section 6.1 presents the data and its conditioning factors, and §6.2 presents an analysis in CBP, showing that multiple reweightings of vocabulary items within the same phase are cumulative and can interact to result in a doubly triggered alternation.

6.1. Data. In §5 we saw root-controlled ATR and nasal harmony in Guébie. There is another harmony process in the language in which a set of grammatical morphemes, namely object-marking enclitics on verbs and plural suffixes on nouns, triggers full vowel harmony on a subset of roots. The term full vowel harmony is used here for harmony that affects all features of the vowels in question, [high, back, round, ATR]. An example is given in 50, where the vowels in the root /bala$^{3.3}$/ undergo full harmony triggered by the third-person human object enclitic, marked as an enclitic with '=' (/=ɔ^{2}/), such that the vowels in the root surface as [ɔ^{2}].

(50) Full vowel harmony

a. ɔ^{3} **bala**$^{3.3}$

3sg.nom hit.pfv

'He hit.'

b. ɔ^{3} **bɔl=ɔ$^{3.2}$**
3sg.nom hit.pfv=3sg.acc
'He hit him.'

When vowel-initial suffixes and enclitics attach to roots in Guébie, the final vowel of the root does not surface, as in 50b. Thus, for monosyllabic roots, with only a single underlying vowel that does not surface in suffixing contexts, we cannot say whether full harmony applies or not, as in 51.

(51) No evidence of full vowel harmony in monosyllabic roots

	ROOT	ROOT+OBJ	GLOSS
a.	ɓə^{31}	ɓ=ɔ^{312}	'finish'
b.	pa^{3}	p=ɔ^{32}	'throw'

Because we have no evidence for whether full vowel harmony affects any monosyllabic roots, and roots longer than disyllables are quite rare in the corpus, this section focuses on disyllabic roots.

All third-person object-marking enclitics trigger full vowel harmony. The complete set of object enclitics is given in Table 4. Human pronouns are given in the left-hand columns and nonhuman pronouns on the right. There is a set form for human singular and plural object markers. The third-person nonhuman pronoun used is determined by the phonology (Sande 2017, 2018b), where the height of the vowels in a noun root determines the choice of pronoun.

Examples of three object enclitics (/=ɔ^{2}, =ɛ^{2}, =ɪ^{2}/) triggering full vowel harmony on three distinct roots are given in 52.[7]

(52) Full harmony in object-marking contexts

	HUMAN		NONHUMAN	
	SINGULAR	PLURAL	SINGULAR	PLURAL
1st	e^{3}, ø	a^{1}, aɲɛ$^{1.1}$	—	—
2nd	e^{1}, mɛ^{2}	a^{2}, aɲɛ$^{2.2}$	—	—
3rd	ɔ^{2}	wa^{2}	ɛ^{2}, a^{2}, ʊ^{2}	ɪ^{2}, wa^{2}

Table 4. Guébie object markers.

	VERB	OBJECT	VERB+OBJ	GLOSS
a.	jili$^{2.3}$	=ɔ^{2}	jɔl=ɔ$^{2.32}$, *jil=ɔ$^{2.32}$	'steal him'
b.	jili$^{2.3}$	=ɛ^{2}	jɛl=ɛ$^{2.32}$, *jil=ɛ$^{2.32}$	'steal it'
c.	jili$^{2.3}$	=ɪ^{2}	jɪl=ɪ$^{2.32}$, *jil=ɪ$^{2.32}$	'steal them'
d.	jɪla$^{3.2}$	=ɔ^{2}	jɔl=ɔ$^{3.2}$, *jɪl=ɔ$^{3.2}$	'ask him'
e.	jɪla$^{3.2}$	=ɛ^{2}	jɛl=ɛ$^{3.2}$, *jɪl=ɛ$^{3.2}$	'ask it'
f.	jɪla$^{3.2}$	=ɪ^{2}	jɪl=ɪ$^{3.2}$, *jɪl=ɪ$^{3.2}$	'ask them'
g.	bala$^{3.3}$	=ɔ^{2}	bɔl=ɔ$^{3.2}$, *bal=ɔ$^{3.2}$	'hit him'
h.	bala$^{3.3}$	=ɛ^{2}	bɛl=ɛ$^{3.2}$, *bal=ɛ$^{3.2}$	'hit it'
i.	bala$^{3.3}$	=ɪ^{2}	bɪl=ɪ$^{3.2}$, *bal=ɪ$^{3.2}$	'hit them'

Additionally, there are two plural suffixes, /-i^{2}, -a^{2}/, both of which trigger full vowel harmony.

[7] The tone of all third-person object markers is a level 2. The underlying tone of the object marker and other affixes is not overridden by the tone of the root, and does not override the underlying tone of the root. The root tone surfaces, followed by the tone of the suffix or enclitic. In 52d–f the final level of the root is the same as the tone of the object marker, in which case we do not see two copies of a level 2 tone. In 52g–i the root tone is a level 3, which spreads over as many vowels as necessary such that every vowel is associated to a tone. In the context of a suffix or enclitic, when the suffix or enclitic vowel is associated with its own tone and the final root vowel fails to surface, the root tone is associated to only one vowel, as opposed to two in its bare form.

(53) Full harmony in plural contexts

	SINGULAR	PLURAL	GLOSS
a.	ɓele$^{2.2}$	ɓil-i$^{2.2}$	‘cow’
b.	mɛnɛ$^{3.3}$	man-a$^{3.2}$	‘animal’

Other enclitics and suffixes, including those that are phonologically identical to object enclitics or plural suffixes, fail to trigger full harmony. Recall that the shape of the 3SG.HUM object enclitic is [=ɔ^{2}]. The passive suffix, which is segmentally and tonally identical, does not trigger harmony.

(54) Lack of full harmony in passive contexts

	VERB	VERB+PASS	GLOSS
a.	bala$^{3.3}$	bal=ɔ$^{3.2}$, *bɔl=ɔ$^{3.2}$	‘be hit’
b.	jɪla$^{3.2}$	jɪl=ɔ$^{3.2}$, *jɔl=ɔ$^{3.2}$	‘be asked’

Thus the environments in which full harmony occurs cannot be characterized solely by phonological features. Additionally, first- and second-person object enclitics, despite having the same morphological and syntactic distribution as third-person object markers, do not trigger replacement: /jɪla$^{3.2}$=a^{2}/ ‘ask=2PL.ACC’ → [jɪl=a$^{3.2}$]. Full harmony occurs only in specific morphological environments, namely, when a third-person object marker or plural suffix is present.

Full harmony is also lexically conditioned; it applies only to a subset of Guébie roots. This subset makes up 33.4% of the lexicon, based on a sample of 1,839 roots, 614 of which are subject to full vowel harmony. Two speakers judged the acceptability of 1,869 different roots. Judgments were remarkably consistent across the speakers; they agreed on 1,839 (or about 98%) of roots.

The subset of roots affected by full vowel harmony does not form a semantic or phonological natural class. Phonologically, there is a tendency for roots that undergo full harmony to contain a CVCV string where the second C is /l/ and where the two vowels are identical (Sande 2017:Ch. 5.2.2). However, no set of phonological traits exhaustively and exclusively picks out the set of roots that alternate. For example, there are minimal pairs like *jili*$^{2.2}$ ‘be fat’, which undergoes harmony, and *jili*$^{2.2}$ ‘fish’, which does not.

Semantically, there is no coherent feature of verbal or nominal roots that picks out all and only the roots that alternate. For example, *ŋʷɔnɔ*$^{4.4}$ ‘woman’ and *ɲɔkpɔ*$^{3.1}$ ‘person’ undergo full harmony, while *ŋudi*$^{3.1}$ ‘man’ does not, and masculine/feminine gender distinctions do not play a role in any aspect of the grammar. Similarly, there are multiple verbal roots in Guébie that mean ‘bring’ or ‘carry’. Some of these undergo harmony, and others do not. For example, *lamɛ*$^{2.2}$ ‘bring’ does not undergo harmony, while *dələ*$^{3.3}$ ‘carry/bring’ does. It is not the goal of this article to explain which roots fall into which class.[8] However, due to the fact that phonological or semantic traits cannot on their own pick out which roots alternate, I assume for the purposes of this article that roots are lexically specified as alternating or not.

Interestingly, the same set of roots that undergo full vowel harmony can also optionally undergo vowel deletion, where a CVCV form surfaces as CCV.[9] For example, /bala$^{3.3}$/ ‘hit’ can surface as [bla^{3}], and /jɪla$^{3.2}$/ ‘ask’ can surface as [jla^{32}]. This reduction process is optional; it is not conditioned by morpheme or syntactic environment, but is more likely to occur in fast, casual speech than in careful speech.

[8] Though note that the distribution of types of words that alternate could be captured by a weighted constraint model (Sande 2017, 2018c) or by a structured lexicon, as McPherson (2019) argues for Seenku.

[9] When /l/ surfaces as the second C in a CC cluster that results from vowel reduction, it is produced as [r]. For simplicity I write all surface [r]s as [l] here, since /r/ and /l/ are not contrastive in Guébie.

(55) CVCV to CCV reduction in the same subset of words that undergo full harmony (syl_20161207)

	CVCV	CCV	GLOSS
a.	jili$^{2.2}$	jli^{2}	‘be fat’
b.	kpolo$^{3.1}$	kplo^{31}	‘be clean’
c.	bala$^{3.3}$	bla^{3}	‘hit’
d.	jɪla$^{3.2}$	jla^{32}	‘ask’
e.	ɟulu$^{3.3}$	ɟlu^{3}	‘salt’
f.	gɔlɔ$^{3.3}$	glɔ^{3}	‘pain’
g.	kuɓə$^{3.1}$	kɓə^{31}	‘yesterday’
h.	dowe$^{3.1}$	dwe^{31}	‘baboon’
i.	abiɟa$^{3.2.2}$	abɟa$^{3.2}$	‘Abidjan’
j.	gʷɛɲɛnɛ$^{2.4.3}$	gʷɲɛnɛ$^{24.3}$	‘last one’
k.	wɔtɔlɔ$^{3.2.2}$	wɔtlɔ$^{3.2}$	‘be cold’

Disyllabic roots (55a–h) show the same pattern as two-syllable strings within longer roots (55i–k). Either the first or second vowel of a trisyllabic root can be deleted, depending on the phonotactic traits of each CVCV sequence within that root.

The forms in 55a,c,d are the same roots that were shown to undergo full harmony in 53. Roots that do not undergo full harmony cannot be reduced from CVCV to CCV; their CCV forms are ungrammatical. A set of such words is given in 56. The words in 56 are (near-)minimal pairs with those in 55, showing that it is not purely the phonotactics of a given root that allows for alternation.

(56) Irreducible words (syl_20161207)

	CVCV	CCV	GLOSS
a.	jili$^{2.2}$	*jli^{2}	‘fish’
b.	ɟʊla$^{3.2}$	*ɟla^{32}	‘take/borrow’
c.	gɔlɔ$^{2.3}$	*glɔ^{23}	‘canoe’
d.	kpoke$^{2.4}$	*kpke^{24}	‘crocodile’

Those roots that alternate between CVCV and CCV are the same subset of roots whose vowels alternate in full harmony contexts. I refer to these as ALTERNATING ROOTS. Roots that fail to alternate in both reduction and full harmony contexts are referred to as NONALTERNATING.

This alternation between CVCV and CCV is common across Kru languages (cf. Marchese 1979). In the case of some Kru languages, CVCV is said to be the underlying form, as in Guébie, undergoing vowel deletion in fast or casual speech. For others, CCV is claimed to be underlying, sometimes produced CVCV in careful speech. For languages in the latter group, the first vowel in the surface CVCV form is predictable given the second vowel (Zogbo 2019:9–10). This second analysis, where /CCV/ can surface as [CVCV], is reminiscent of ‘Dorsey’s law’ in Winnebago (Miner 1979, 1989, Hale & White Eagle 1980, Hayes 1995), where a vowel is inserted into a CLV word to break up the cluster. The epenthetic vowel in Winnebago matches the following one: /prás/ → [parás] (Miner 1979:27).

In Guébie, unlike Winnebago and certain other Kru languages, the first vowel in a CVCV word is not predictable given its CCV counterpart. For example, *jɛla*$^{3.2}$ ‘appear’ and *jɪla*$^{3.2}$ ‘ask’ both surface as *jla*^{32} in their reduced form. Given the reduced form *jla*^{32}, we cannot predict what the inserted vowel should be, and in fact we find that it corresponds to two distinct CVCV forms, *jɪla*$^{3.2}$ and *jɛla*$^{3.2}$. For this reason, as in Sande 2017 I assume that all surface CCV forms are underlyingly CVCV in Guébie, and that the initial vowel can optionally be elided.

We have seen that full harmony in Guébie is sensitive to the presence of certain functional morphemes—object enclitics and plural suffixes—as well as the identity of the lexical root present. Both an alternating root and a triggering morpheme must be present for full harmony to surface.

6.2. Analysis. Full vowel harmony is both morphologically and lexically conditioned. It occurs only in the environment of particular functional morphemes (object enclitics and plurals), and it applies to a subset of roots that cannot be characterized entirely by their phonological or syntactico-semantic features. In this section, I analyze the interaction of morphological and lexical conditioning of full harmony in CBP via cumulative morpheme-specific constraint-weight adjustments. We will see that the combined effects of two independent reweightings of the same constraint, inserted on vocabulary items, results in full vowel harmony on the surface. Even though one of the conditioning factors is the presence of a particular functional morpheme and another is the presence of a particular lexical item, these two conditioning types are handled uniformly in CBP, as constraint reweightings specific to vocabulary items.

The phonological constraints relevant for motivating the full harmony process in Guébie include the vowel harmony constraint, VHarmony for short, and a faithfulness constraint. As with the harmony constraints in §5.2, I adopt ABP-style constraints (Hansson 2014). These are given below.

(57) Ident-IO(V) (Ident-V): Assign one violation if an output vowel's features differ from the corresponding input segment.

(58) $*[\alpha F][\beta F]_{[+\text{syllabic}]}$ (VHarm(ony)): A segment with a given set of feature values may not directly precede another segment with a different set of feature values in the ordered set of output segments that are [+syllabic]. Assign one violation for each output form where at least one pair of vowels or consonants meets these criteria.

Note that, as in the preceding section, these constraints are not evaluated gradiently, but wholesale for each prosodic word. The default weights of these constraints are given in 59.

(59) Default weights for suffix-triggered harmony

Constraint	Weight
Ident-V	3
VHarm	0.5

As with the identity and harmony constraints in §5.2, Ident-V outweighs VHarmony in the default grammar, resulting in faithful outputs and no harmony.

Recall that full vowel harmony on roots occurs in the presence of plural suffixes and object enclitics, but not other suffixes. I propose that plural suffixes and object markers are differentiated from other affixes by their association with a constraint reweighting. A reweighted cophonology applies only in the presence of these morphemes.

The vocabulary item for the third-person human singular object marker is given in 60. All third-person object markers and both plural suffixes are assumed to be associated with the reweighting in $\mathcal{R}_5$.

(60) Object marker vocabulary item

$$[\text{3sg.hum.acc}] \leftrightarrow \left\{ \begin{array}{ll} \mathcal{F}: & /ɔ^2/ \\ \mathcal{P}_5: & =X]_\omega \\ \mathcal{R}_5: & \text{VHarm}^{+1.5}, \text{Ident-V}^{-0.5} \end{array} \right\}$$

The weights in 60 add to those in the default grammar to give us VHarmony = 2 and Ident-V = 2.5. Notice that Ident-V still outweighs VHarmony, so the faithful output will be judged optimal, as in the default. On their own, these weights are not enough to result in harmony, due to the presence of the still highly weighted IDENT-V constraint.

The second half of the proposed analysis is that alternating roots are also associated with a reweighting of constraints, $\mathcal{R}_6$, shown in 61.

(61) Alternating root vocabulary item

$$[\sqrt{hit}] \leftrightarrow \left\{ \begin{array}{ll} \mathcal{F}: & /\text{bala}^{3.3}/ \\ \mathcal{P}_6: & [X_\omega] \\ \mathcal{R}_6: & \text{VH}{\small\text{ARM}}^{+1}, \text{I}{\small\text{DENT}}\text{-V}^{-1} \end{array} \right\}$$

Instead of indexing each root as alternating or nonalternating, either each root is associated with a constraint weighting that demotes IDENT-V (alternating roots), or its specified $\mathcal{R}$ is the empty set (nonalternating roots). In the latter case the default weights will apply, and we will not see alternation.

On their own, the weights in 61 combine with the default grammar to give us VHARMONY = 1.5, IDENT-V = 2. Again, this is not enough to result in full harmony, since the faithfulness constraint still outweighs the harmony constraint. However, when both a morphosyntactic harmony trigger and an alternating root are present in the same spell-out domain, the default weights are modified according to both subweights, and the cumulative effects are enough to result in harmony.

(62) Cumulative effects of morpheme-specific cophonologies

Grammar	IDENT-V	VHARM
Default	3	0.5
Obj/Pl	−0.5	+1.5
Alt. root	−1	+1
Total weight	*1.5*	*3*

If either the alternating root or the triggering morpheme (object marker or plural)—or both—is absent from the spell-out domain being evaluated, the grammar picks out the faithful candidate as optimal, showing no vowel harmony. However, the combined effect of the cumulative subweights results in full harmony via constraint interaction. The four-way interaction of alternating and nonalternating roots with triggering and nontriggering affixes is shown in 63.

(63) When harmony applies

	TRIGGER (OBJ)	NONTRIGGER (PASS)
ALTERNATING ROOT	Harmony	No harmony
NONALTERNATING ROOT	No harmony	No harmony

Tableaux showing the phonological constraint interactions in each of the above four environments are given below. The harmony context is provided first (cf. 53). When both an alternating root and an object enclitic are present, the relevant weights are VHARMONY = 3, IDENT-V = 1.5, and full vowel harmony throughout the word applies.

(64) Composition of alternating root plus object marker
$/[_\omega\ \text{bala}^{3.3}]{=}\text{ɔ}^2/^{(\mathcal{P}^{5+6},\ \mathcal{R}^{5+6})}$

(65) Alternating root + object enclitic: Harmony

$/[_\omega$ bala$^{3.3}]$=ɔ^2/	VHARMONY 3	IDENT-V 1.5	*H*
a. $[_\omega$ bal^3=ɔ$^2]$	1		3
b. ☞ $[_\omega$ bɔl^3=ɔ$^2]$		1	1.5

I assume here that a separate set of highly weighted NOHIATUS constraints in the language accounts for the deletion of the final root vowel in the context of a vowel-initial suffix or enclitic. We never see vowel hiatus in this context in Guébie, so the remainder of this section only considers candidates satisfying NoHiatus.

When an alternating root is present, but an object marker or plural suffix is not, no harmony applies (cf. 54). The composition of an alternating root plus any other suffix, such as the passive, is subject to the alternating root subweighting, $\mathcal{R}_5$. However, the weighting in $\mathcal{R}_5$ does not adjust the default grammar weights enough to have an observable effect.

(66) Composition of alternating root plus passive suffix
/[$_{\omega}$ bala$^{3.3}$]=ɔ^{2}/$^{(\mathcal{P}^6,\ \mathcal{R}^6)}$

(67) Alternating root + passive: No harmony

/[$_{\omega}$ bala$^{3.3}$]=ɔ^{2}/	Ident-V 2	VHarmony 1.5	*H*
a. ☞ [$_{\omega}$ bal^{3}=ɔ^{2}]		1	1.5
b. [$_{\omega}$ bɔl^{3}=ɔ^{2}]	1		2

When an object enclitic is present, but on a root of the nonalternating type like *ɟʊla*$^{3.2}$, no harmony applies. In this case, the composition of nonalternating root and triggering morpheme is subject to $\mathcal{R}_5$, but not to $\mathcal{R}_6$, resulting in the faithful candidate surfacing as optimal.

(68) Composition of nonalternating root plus object marker
/[$_{\omega}$ ɟʊla$^{3.2}$]=ɔ^{2}/$^{(\mathcal{P}^5,\ \mathcal{R}^5)}$

(69) Nonalternating root + object enclitic: No harmony

/[$_{\omega}$ ɟʊla$^{3.2}$]=ɔ^{2}/	Ident-V 2.5	VHarmony 2	*H*
a. ☞ [$_{\omega}$ ɟʊl^{3}=ɔ^{2}]		1	2
b. [$_{\omega}$ ɟɔl^{3}=ɔ^{2}]	1		2.5

When neither trigger is present—that is, when neither an alternating root nor an object marker or plural suffix is part of the spell-out domain—the default grammar applies, resulting in no harmony.

(70) Composition of nonalternating root plus passive suffix
/[$_{\omega}$ ɟʊla$^{3.2}$]=ɔ^{2}/

(71) Nonalternating root + passive: No harmony

/[$_{\omega}$ ɟʊla$^{3.2}$]=ɔ^{2}/	Ident-V 3	VHarmony 0.5	*H*
a. ☞ [$_{\omega}$ ɟʊl^{3}=ɔ^{2}]		1	0.5
b. [$_{\omega}$ ɟɔl^{3}=ɔ^{2}]	1		3

The combined effect of two subweightings results in full vowel harmony only when both of the following are present:

(i) a plural suffix or object enclitic, and
(ii) an alternating root.

The fact that demotion of the vowel identity constraint Ident-V is inherently associated with alternating roots accounts not only for their behavior in full harmony contexts, but also for the fact that only this subset of roots can show vowel reduction. We could imagine a constraint with a preference for monosyllabic words, or for CCV over CVCV words (see Green & Diakite 2008 for such a set of constraints used to account for vowel reduction in colloquial Bamana (Mande)). If this constraint is weighted 1 lower than the default weight of IDENT-V, then demotion of IDENT-V by 1 in the context of alternating roots will result in both candidates, CVCV and CCV, being equally harmonic. This model predicts that 50% of alternating roots will be produced with vowel deletion (CCV), and that the other 50% will be produced faithfully as CVCV.[10] While we do not have a large enough corpus of spoken Guébie data to determine the frequency with which each word is produced as CVCV versus CCV, variation is easily accounted for in a weighted constraint model, in particular, a maximum entropy (Goldwater & Johnson 2003) or noisy harmonic grammar (Boersma & Pater 2016), but would be much more difficult to account for in a ranked constraint grammar.

Deletion, or reduction to CCV, will never occur with nonalternating roots, because they are never spelled out in the same domain as alternating roots, which are associated with the demotional reweighting of IDENT-V.

One possible limitation of this analysis is that it assumes that all 600+ alternating roots are independently associated with the same reweighting of constraints. However, the demotion of IDENT-V accounts for two vowel-alternation phenomena that these roots and no others undergo. Additionally, this analysis makes no claims about the structure of the lexicon. It would certainly be possible for the lexicon to be structured such that all alternating roots are in a relation, associated with a single reweighting of constraints. This would allow for a single instance of the constraint-weight adjustments affecting alternating roots, rather than listing the same readjustments for each alternating root individually. Overall, a structured lexicon would result in economy, such that the reweighting would not need to be specified 600 separate times in the lexicon. This structured lexicon could also unify the constraint-reweighting-associated object and plural markers. See, for example, McPherson (2019), who assumes a structured lexicon in Seenku (Mande, Burkina Faso).

The result of the proposed analysis is a morphologically and lexically conditioned phonological process via cumulative cophonologies. The following section discusses possible alternative analyses for multiply triggered phonological alternations like this one. Sande 2019 examines a wide range of phonological alternations that surface only in the presence of multiple morphological or lexical triggers, showing that cumulative CBP can account for similar phenomena across languages.

7. DISCUSSION. We have seen that by associating subweights of phonological constraints with particular vocabulary items, and allowing those cophonologies to scope over syntactic phases, CBP can account for morpheme-specific phonology that affects both cross-word and sub-word domains. Alternative models have been built to handle one of these two types of conditioned processes—for example, indexed constraint theory for lexical and morphological conditioning within a word, versus phase theory and match theory for cross-word effects. Each of these previous frameworks accounts for only a subset of the extraphonological conditioning factors that we see across languages, or even within a single language.

A line of recent work combines a phase-based spell-out with constraint-based phonology to account for phonological locality effects (Pak 2008, McPherson 2014, Jenks & Rose 2015, McPherson & Heath 2016, Sande 2017, Kastner 2019). CBP builds on this work, providing a specific implementation of the morphology/phonology inter-

[10] Identity constraints are typically not violated by deletion in the phonological literature (McCarthy & Prince 1995). However, we could imagine this IDENT-V constraint as instead a more general faithfulness constraint to vowels, which is violated both by any change to input vowel features and by vowel deletion.

face that accounts for a wide array of phenomena and is integrated into a distributed morphology–style grammar. In addition to accounting for a wider array of phenomena than previous frameworks, there are three key predictions of CBP: (i) the domain of phonological evaluation is the phase, (ii) the phonological component can only access or reference phonological material, and (iii) phonological phenomena can have multiple extraphonological triggers as long as they are introduced within the same phase domain. Each of these is discussed in turn throughout the remainder of this section.

7.1. The domain of phonological application. The scalar tone-shift process discussed in §4 involves a morphologically conditioned phonological process whose effects cross word boundaries. Previous models of phonological evaluation at the word level, such as lexical phonology and morphology (Kiparsky 1982), stratal OT (Bermúdez-Otero 1999, 2012, Kiparsky 2000, 2008), and traditional cophonology theory (Orgun 1996, Inkelas & Zoll 2005), do not predict this type of morpheme-specific cross-word effect. In stratal OT, for example, phenomena that cross word boundaries are expected to be general, applying in all contexts across the language.

Comparing previous frameworks, one benefit of stratal frameworks like lexical phonology and stratal OT over parallel OT is that they allow for sub-word phonological domains, where nongeneral phonological processes might apply. For example, the ATR and nasal harmony in §5 could be analyzed as a stem-level phonological phenomenon in stratal OT, where the stem-level constraint ranking or weighting ensures harmony over faithfulness, Harmony >> Ident-IO. Then, affixes that attach outside the stem level fail to participate in harmony because faithfulness outranks the harmony-motivating constraints at the word level of evaluation, Ident-IO >> VHarmony.

However, assuming the three strata of stem, word, and phrase used in traditional stratal OT, there is no way to specify that a phonological process holds in a domain larger than a word, but smaller than the phrase or utterance. In the tone shift discussed in §4, we saw a single tone shift affecting subject and verb, two separate words, but not affecting the tone of the utterance as a whole. A number of other languages have been shown to display tonal processes that cross word boundaries but are limited to particular syntactic domains (cf. high tone spreading in Xitsonga, which is limited to prosodic phrases, which tend to align with utterance-internal syntactic phase boundaries (Selkirk 2011:443); see also Harry & Hyman 2014, Marlo et al. 2015, Hyman 2018, Rolle 2018). We could imagine proposing more than three levels in a stratal OT account (cf. Buckley 1994, Jones 2014), but then we would be adding additional levels of phonology-specific domains that just happen to correspond with syntactic phase boundaries. Limiting the domain of phonological evaluation to phase boundaries is more restricted and makes clearer predictions than a version of stratal OT with a flexible number of levels. It is also more economical, because phase boundaries are already needed in the grammar.

Some phenomena have been said to be more likely than others to show sensitivity to syntactic category or to cross word boundaries. These include harmony (cf. cross-word vowel harmony in Akan; Kügler 2015), as well as prosodic phenomena such as tone spreading, tone sandhi, and stress assignment (Smith 2011). While it is true that category-specific and phrasal phenomena tend to be prosodic or involve harmony, tone and harmony are among the only phonological alternations that apply long-distance, even within word boundaries. Consider, though, that there are certainly domain-limited phenomena such as hiatus resolution within but not across prosodic boundaries, as described by Newell and Piggott (2014) for Ojibwe. These phenomena apply locally, but within specific domains: the local context of two adjacent vowels triggers hiatus resolution, but only within and not across particular boundaries. For Ojibwe, Newell and Piggott (2014) analyze this domain-limited hiatus resolution as sensitive to syntactic phase boundaries. Hiatus resolution is not inherently a prosodic phenomenon, but it can still be sensitive to syntactic domain. I propose that the fact that prosodic and harmony-related effects are the most commonly discussed in the syntax/phonology literature is not because there is something inherently special about tone spreading and harmony in comparison to other phonological effects. Rather, tone spreading and harmony are inherently long-distance phenomena, even when they apply within word boundaries. In CBP, any phonological alternation can be limited to a particular syntactic domain (phase) via constraint-weight adjustments associated with vocabulary items inside, and not outside, that domain, accounting for prosodic and segmental effects in a unified way.

CBP accounts for a range of phenomena previously discussed in separate literatures and referred to by separate terms: morphologically conditioned phonology or process morphology (Inkelas 2008), sublexical phonology (Gouskova & Becker 2013, Becker & Gouskova 2016), lexically specific phonology (Itô & Mester 1995, 1999, Alderete 2001, Smith 2001, Pater 2010, Coetzee & Pater 2011), patterned exceptions (Zuraw 2000, 2010, Boersma 2001, Kager 2009), prosodically sensitive phonology (Nespor & Vogel 1986, Selkirk 1986, 2009, 2011, Elfner 2012), and syntactic-domain-conditioned phonology (Chomsky 2001, 2008, Richards 2016). Within CBP, these are modeled uniformly, as morpheme-specific constraint weights that scope over syntactic phases.

7.2. CAN PHONOLOGY DIRECTLY REFERENCE MORPHOSYNTAX? Another way in which CBP differs from alternative models of conditioned phonological processes is in the need for phonology to make direct reference to morphosyntactic information like lexical categories and syntactic features. For example, in indexed constraint theory (Itô & Mester 1995, 1999, Fukazawa 1998, Pater 2007, 2010, Jurgec & Bjorkman 2018) one could account for the lack of ATR and nasal harmony on the nominalizing suffix discussed in §5 by appealing to a faithfulness constraint indexed to the nominalizing morpheme itself, as in 72.

(72) IDENT-IO(NMLZ): Assign a violation for each segment associated with the nominalizing suffix whose output features differ from the features of the corresponding segment in the input.

This constraint, ranked above or weighted more heavily than the constraints ATRHARMONY and NASALHARMONY, would ensure that the nominalizing morpheme surfaced faithfully. And a general identity constraint could at the same time be ranked or weighted lower than the harmony constraints, such that morphemes other than the nominalizer would undergo harmony. However, this indexed constraint requires that the phonological component have access to morphosyntactic featural information. Its definition references the featural information of terminal nodes, differentiating segments that are associated with the input nominalizing morpheme from segments associated with other morphemes.

In certain conceptions of vocabulary insertion in the distributed morphology framework, when phonological information is inserted into the tree, morphosyntactic featural information is no longer present (Halle 1990, Trommer 1999, Bobaljik 2000). Under this strict-rewriting view of vocabulary insertion, morphosyntactic features such as {NMLZ} are no longer available by the time phonological evaluation occurs, and thus a constraint like that in 72 would be impossible. That is, indexed constraints are incompatible with a morphological component where morphosyntactic features are overwritten by phonological information during vocabulary insertion. An indexed constraint view is compatible only with a view of morphology and its interfaces in which morphosyntactic information persists through the morphosyntactic components to phonological evaluation. Outside of distributed morphology, a number of arguments from an array of theoretical perspectives have been made against the phonological component having access to morphosyntactic information; for a thorough discussion, see Scheer 2011. In the tradition of cophonology theory specifically, it is seen as a benefit that phonological constraints do not directly reference morphosyntax (Orgun 1996, Inkelas & Zoll 2007). Inkelas and Zoll demonstrate the distinct predictions of cophonology theory and indexed constraint theory with an example of tone replacement in Hausa (2007:146–48). They show that a single, global ranking with constraints indexed to particular morphemes cannot tie the morpheme-specific effects to particular limited domains, as is required to account for phenomena like the Hausa tone replacement, or the Guébie harmony described here in §§5 and 6.[11]

Like indexed constraint theory, interface constraints in match theory (Selkirk 2009, 2011) also make direct reference to morphosyntax in that they match prosodic edges to edges of syntactic constituents.

(73) Match(α, π) (Selkirk 2011:451): The left and right edges of a syntactic constituent of type α in the input syntactic representation must correspond to the left and right edges of a prosodic constituent of type π in the output phonological representation.

In match theory, interface constraints apply at a separate level of evaluation from other phonological constraints, mapping syntactic to prosodic structure at an additional step in the derivation. CBP combines prosodic structure building into the single phonological evaluation component, with the Maximize Prosodic Domains constraint and $\mathcal{P}$ specifications. Unlike indexed constraint theory and match theory, CBP follows cophonology theory in avoiding the need for phonological constraints to directly reference morphosyntactic information. In CBP, the phonology only needs access to the phonological content of items in the spell-out domain, provided during vocabulary insertion. This phonological content contains phonological feature information, prosodic specifications, and constraint subweights; reference to morphosyntactic information during phonological evaluation is unnecessary.

7.3. Doubly conditioned phonological phenomena. Lastly, CBP is particularly well suited for modeling phonological processes with multiple morpheme-specific triggers, like the Guébie full vowel harmony described in §6. In CBP, multiple morpheme-specific $\mathcal{R}$ specifications introduced within a single phase can manipulate the constraint weights that apply to that phase domain. If multiple $\mathcal{R}$s affect the same constraints, we could see a cumulative effect, as discussed in §6.2. Such doubly triggered processes are well attested across languages; see, for example, DuBois 1985 on doubly conditioned ablaut in Mayan, and Sande 2019 for an analysis of the Mayan data and other doubly conditioned phenomena in CBP.

Cumulative effects like this one pose a challenge for single-grammar theories such as indexed constraint theory, in which there is a single, global constraint ranking that applies to the entire language. One could index a harmony constraint to a particular set of grammatical morphemes (in this case plural and third-person object markers) or to a particular lexical class (in this case an arbitrary set of roots).

[11] See Pater 2007, 2010 on a potential solution for addressing the locality of indexed constraint effects; though note that Pater's view is in fact too limited to account for the cross-word phenomena discussed here and in Sande et al. 2019. See Sande et al. 2019 for further discussion.

(74) VHARMONY(Plural, OM): Assign one violation for each pair of vowels in an output prosodic word containing a plural suffix or object marker that differ in at least one phonological feature.

(75) VHARMONY(Class2): Assign one violation for each pair of vowels in an output prosodic word containing a class 2 lexical item that differ in at least one phonological feature.

Both constraints (74–75) would be present in the global phonological grammar, and in order to show any effect both must be ranked or weighted above IDENT faithfulness constraints. Then, if either one of the triggers, a plural or object marker, or a root of the appropriate lexical class, is present, harmony would apply. However, this prediction does not match what we see in the data; harmony applies only if both triggers are present in the same spell-out domain.

Using weighted constraints, we could imagine a set of weights for the above constraints that results in a GANG EFFECT.[12] That is, the effect of a single constraint, VHARMONY(Plural, OM), would not be enough to trigger harmony on its own, but it could gang up with VHARMONY(Class2) to result in harmony only when both constraints would otherwise be violated. This type of ganging effect could give us an optimal surface form of global harmony when both the lexical and morphological trigger are present, but not otherwise. However, full harmony in Guébie is not global. It applies only to elements introduced within the phase containing the trigger, or in earlier phases. Elements introduced in later syntactic phases, such as nominalizers, or within the nominal domain, such as definite markers, are unaffected by full harmony: /ɓele-i-a/ 'cow-PL-DEF' → [ɓil-i-a], *[ɓil-i-i] 'the cows'.

The challenges for indexed constraint theory in accounting for doubly conditioned phenomena are two-fold: (i) how to prevent one of the constraints, say VHARMONY(Plural, OM) or VHARMONY(Class2), from having an effect when the other relevant trigger is not present, and (ii) how to account for locality of application of the relevant phonological process. While ganging or local constraint conjunction could serve to address the first of these challenges, the second remains.

In CBP, neither of these issues is a challenge to overcome: morpheme-specific effects accumulate within a phase, and, in the case of doubly triggered phenomena, apply only when the weights associated with both triggers are introduced in the same domain. Phonological evaluation at phase boundaries, and the inaccessibility of morpheme-specific subweights during later phases, results in clear predictions about the locality of morpheme-specific effects, as laid out in the phase containment principle, as was defined in 10 above.

8. CONCLUSION. Phonological processes are often sensitive to factors external to phonology, in addition to phonological environment. Morpheme, lexical item, and syntactic domain can condition the application of a phonological alternation or process. This article has shown that within a single language, Guébie (Kru, Côte d'Ivoire), phonological processes are conditioned by these factors:

- A functional morpheme: Guébie scalar tone shift in imperfective contexts, and full harmony in object marking and plural contexts.
- Lexical class: Guébie full harmony on 33.4% of roots.
- Syntactic domain: Guébie ATR and nasal harmony within the verbal projection, and scalar tone shift across word boundaries.

[12] Another solution would be to allow local constraint conjunction (Smolensky & Legendre 2006, Shih 2016).

The CBP analysis presented here expands on the introduction of the CBP framework in Sande & Jenks 2018, relying on an enriched notion of vocabulary items and phase-based application of phonological evaluation to account for all three phenomena in a unified way.

While many previous models have accounted for a subset of morpheme-specific phonological alternations, CBP synthesizes the tools needed to account for sub-word and cross-word morpheme-specific effects, with very few modifications to existing theoretical assumptions. CBP builds on work combining distributed morphology and constraint-based evaluation (Pak 2008, Wolf 2008, Jenks & Rose 2015, McPherson & Heath 2016, Sande 2017, Kastner 2019), specifying the mechanism by which the phonological grammar is modified during the interface interaction of morphology and phonology to account for domain-specific and morpheme-specific phonology. CBP adapts traditional cophonologies to account for a wider array of data, while still making clear predictions about locality and scope, as specified in the phase containment principle.

With morpheme-specific constraint weights that scope over constituents determined by syntactic phasehood, we can account for multiple types of extraphonological conditioning within a single model.

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