Mirror Principle Violations are Phonologically Conditioned: Evidence from Choguita Rarámuri

Felicitas Andermann[a], Jona L. Sommer [b] & Jochen Trommer[c*]

[a]Universität Leipzig – felicitas.andermann@uni-leipzig.de,
[b]Universität Leipzig – lm04kiji@studserv.uni-leipzig.de
[c]Universität Leipzig – jtrommer@uni-leipzig.de

A predominant assumption in the vast literature on the Mirror Principle is that exceptions to the principle are due to *morphology* (Hyman 2003; Ryan 2010; Popp 2021). In this paper, we provide evidence, based on Rarámuri, that the role of *phonology* in accounting for Mirror Principle violations is much bigger than usually assumed. According to Caballero (2008, 2010), only a small part of the ordering patterns in the language is prosodically conditioned, Here, we argue that Caballero's prosody-based explanation should be extended to *all* cases of Mirror Principle violations in the language. The central advantage of the phonological approach is that it directly links the different behaviors of specific affixes in ordering to their independent morphophonological differences. To show the viability of a fully phonological analysis, we provide a full reanalysis of Caballero's data in Stratal Optimality Theory assuming prosodic subcategorization in terms of virtual structure (Lionnet & Rolle 2020) and Gradient Symbolic Representations (Smolensky & Goldrick 2016; Zimmermann 2018, 2021; Hsu 2022).

Keywords: Rarámuri; Affix Order; Prosody; Gradient Symbolic Representations; Stratal OT

1 Introduction

In Choguita Rarámuri (Tarahumara, Uto-Aztecan, spoken in south-western southwestern Chihuahua, Mexico), as described in Caballero (2008, 2010, 2022), there are six suffixes that exhibit alternative orders with respect to each other: Applicative /-ki/, Causative /-ri/, /-r/ and /-ti/, Desiderative /-na(le)/, Associated Motion /-si(mi)/ and Evidential /-ca(ne)/. Some of these ordering alternatives correspond to different semantic composition, as exemplified for Causative and Desiderative in (1-a,b) (here and in the following, we write '$X \triangleright Y$' to indicate that X has scope over Y). However, there are also non-compositional orderings, as in (1-c), where the Causative scopes over the Desiderative, but the Causative suffix /-r/ is closer to the stem than the Desiderative suffix /-na(le)/, or in (2), where the Evidential scopes over the Desiderative but the Evidential suffix is closer to the stem than the Desiderative suffix. All data here and throughout the paper are taken from the published work by Caballero cited as (*year*:*page number*:*example number*):

(1) *Alternative orders of Causative and Desiderative*

a. DES $\triangleright$ CAUS (compositional order)
tamí nará-**t**-**nare**
/tamí nará-**ti**-**na(le)**/
1SG.ACC cry-**CAUS**-**DES**
He wants to make me cry' (2010:180:23-b)

b. CAUS $\triangleright$ DES (compositional order)

*We would like to thank Gabriela Caballero for granting us access to her elicited data and Paul Kiparsky, Barbara Stiebels and the audience of the CyclOp colloquium and the CyclOp retreats for helpful comments. This research has been funded by the DFG project *Cyclic Optimization (CyclOp)*.

baʔwí bahí-**n**-**ti**-ri=ni
/baʔwí bahí-**na(le)**-**ti**-ri=ni/
water drink-**DES**-**CAUS**-PST.PASS=1SG.NOM
'They made me want to drink water' (2010:179:22-b)

c. CAUS ▷ DES (non-compositional order)
rarí-**r**-**niri**-si
/rari-**r**-**na(le)**-si/
buy-**CAUS**-**DES**-IMP.PL
'Make him want to buy!' (2010:198:51-e)

(2) EV ▷ DES (non-compositional order)
atís(i)-**ca**-**nare**
/atísi-**ca(ne)**-**na(le)**/
sneeze-**EV**-**DES**
'It sounds like they want to sneeze' (2010:184:29-a)

The attested variable orderings are summarized in Table 1, where the categories in the top row ('higher') have scope over the ones listed in the leftmost column ('lower').[1] The Evidential /-ca(ne)/ and the Applicative /-ki/ exhibit fixed orders of semantic composition: /-ca(ne)/ always scopes over all other suffixes, and /-ki/ never scopes over any other suffix. The impossible readings are marked by shading and the symbol '✗'. These two suffixes are also the most restrictive ones in the affix orders they allow: Evidential /-ca(ne)/ can only occur inside Desiderative /-na(le)/ but not inside any other of these suffixes, and Applicative /-ki/ only allows for non-compositional ordering with respect to the Causative suffix /-r/ or both Causative suffixes /-r/ and /-ti/. The Desiderative /-na(le)/ can only be closer to the stem than the Causative /-ti/ or /-r/ in a compositional ordering, with the Causative scoping over the Desiderative as in (1-b), but the Causative can be inside the Desiderative in both compositional (1-a) and non-compositional (1-c) orders. The Causative and Associated Motion suffixes exhibit both orderings with respect to each other under, each under both compositional and non-compositional interpretations, and so do the Desiderative and Associated Motion affixes.

[1] Abbreviations used here and throughout the text: APP = Applicative, CAUS = Causative, DES = desiderative, MOT = Associated Motion. Otherwise, we adhere to the Leipzig glossing rules.

higher → lower ↓	APP	CAUS	DES	MOT	EV
APP		APP-CAUS CAUS-APP	APP-DES (DES-APP)	APP-MOT	APP-EV
CAUS	✗		CAUS-DES	CAUS-MOT MOT-CAUS	CAUS-EV
DES	✗	DES-CAUS CAUS-DES		DES-MOT MOT-DES	DES-EV EV-DES
MOT	✗	MOT-CAUS CAUS-MOT	MOT-DES DES-MOT		MOT-EV
EV	✗	✗	✗	✗	

Table 1: Attested and unattested scopes in syntactic and aspectual stem levels (2010:190)

Caballero (2010) shows that the non-compositional ordering of the Evidential /-ca(ne)/ and the Desiderative /-na(le)/ is phonologically conditioned. /-ca(ne)/ always occurs after a sequence of the syllable carrying word stress and an unstressed syllable whether the order is harmonic or disharmonic to compositional semantics. This is directly captured by Caballero through positing that the affix subcategorizes for a foot on its left. On the other hand, Caballero (2010) argues that all other non-compositional orderings in the language are independent from phonology: they are simply language-specific facts about morphology. Caballero (2010) implements this intuition by the bigram constraints in 3 which refer to morphosyntactic not to phonological information. The non-compositional oder of Causative and Desiderative in (1-c) simply follows from assuming that the constraint in (3-a) is high-ranked. The arbitrary character of these constraints is maybe most obvious in its treatment of alternative ordering options. The apparently free variation between Causative and Associated Motion (see the relevant cells in 1) is captured by the two constraints in (3-e) and (3-f) which encode opposite ordering preferences and are assumed to be in variable order in the grammar of Rarámuri.

(3) *Choguita Rarámuri morphotactic constraints* (Caballero 2010:191)

a. C $\prec$ A: Causative precedes Applicative

b. C $\prec$ D: Causative precedes Desiderative

c. D $\prec$ M: Desiderative precedes Associated Motion

d. M $\prec$ D: Associated Motion precedes Desiderative

e. C $\prec$ M: Causative precedes Associated Motion

f. M $\prec$ C: Associated Motion precedes Causative

In this paper, we argue that the Evidential is not the exception, but the rule in Rarámuri: *all* non-compositional orderings are phonologically conditioned. Thus the Causative allomorph /-r/ exhibits a similar prosodic restriction as the Evidential: it consistently appears in the coda of the syllable carrying main stress. This accounts for the non-compositional ordering in (1-c)

An even closer connection of affix order to stress characterizes the Desiderative suffix /-na(le)/. In (4), Desiderative has scope over Associated Motion but /-na(le)/ appears closer to the stem than /-si(mi)/.

(4) DES ▷ MOT *(non-compositional order)*
kurí uʔpá naparí=n ku simí-ka koci-**nál**-**si**-a=n iná-ri
|kurí uʔpá naparí=n ku simí-ka koci-**nále**-**si(mi)**|
/kurí uʔpá naparí=n ku simí-ka koci-**ná(le)**-**si(mi)**-a=ni iná-li(
just last REL=1SG.NOM REV go-GER sleep-**DES**-**MOT**-PROG-1SG.NOM go-PST
'Last time I went there, I wanted to go along sleeping' (2010:189:35-c)
(translation corrected/reconstructed from Caballero's description and Spanish translation)

Of all the suffixes that participate in reordering, /-na(le)/ is the only one that can bear stress, and whenever it occurs closer to the stem than the Associated Motion suffix /-si(mi)/ while scoping over it, it bears stress, like in (4). Moreover, this only ever occurs with unstressed verb roots, such as /koci/ in (4) and /-na(le)/ appears outside /-si/ although /-si/ scopes over /-na(le)/. A straightforward explanation of this connection is that /-na(le)/ in contrast to all other affixes involved in reordering has underlying stress. Since Rarámuri words are bound to an initial 3-syllable stress window, /-na(le)/ moves to the left to provide an underlying stress (and hence avoid epenthetic accent) if the root (which is typically bisyllabic) is itself underlyingly unstressed.

A final pattern where non-scopal affix order correlates with independent morphophonological properties of affixes are length-alternating suffixes which occur either in a long (bisyllabic) or a short (monosyllabic) variant. A case in point is the Associated Motion suffix which appears as [-si] in (4) where it is followed by the progressive suffix /-a/, but as [-simi] if it is word-final as in [keci-simi] chew-MOT 'go around chewing'. The overall generalization is that it appears in its short variant if it is followed by a Stem-Level suffix, but otherwise in its long form. Again, this can be captured by subcategorization. Assuming that /-si/ subcategorizes for a syllable to its right, the choice of the long variant can be understood as a last resort repair to satisfy this requirement if the affix is not followed by another affix. Strikingly, length-alternating affixes also lead to ordering patterns violating the Mirror Principle. Thus in (5), Associated Motion [-si] precedes the Causative suffix /-ti/ even though it has scope over it.

(5) MOT ▷ CAUS *(non-compositional order)*
nihé mi sú-**s**-**ti**-ma sipúci
|nehé mi sú-**si**-**ti** sipúca|
/nehé mi sú-**si(mi)**-**ti**-ma sipúca/
1SG.NOM 2SG.ACC sew-**MOT**-**CAUS**-FUT.SG skirt
'I will go along making you sew the skirt' (2010:188:34-d)

Subcategorization provides a natural account for this pattern: The two involved affixes /-si/ and /-ti/ are final in the Stem domain indicated here by square brackets (see Caballero (2008) and section 3.1 on independent evidence for a stem stratum in Rarámuri). In the expected scopal order [sú-ti-si], Associated Motion /-si/ would not be followed by another (stem) syllable. Counterscopal ordering by leftwards dislocation can thus be understood as a third strategy to ensure satisfaction of the subcategorization requirement for a following syllable.

Taken together, under our reanalysis, all morphological constraints in (3) are replaced by reference to phonology, either to prosodic subcategorization or by minimizing epenthetic accent (in the case of /-na(le)/). This is conceptually preferable: phonological optimization and prosodic subcategorization are independently motivated by many phenomena outside of affix linearization (e.g, by phonologically conditioned allomorphy, see section 2), templatic constraints only serve the very purpose of affix ordering. Moreover the phonological account leads to finer grained predictions than the morphological approach. Thus, as we have already mentioned counterscopal orderings where /-na(le)/ precedes associative motion only seem to occur with verb roots lacking underlying stress and with stress ending up on /-na(le)/. Also Causatives don't behave in a homogeneous way as suggested by the constraints in (3). In specific combinations, for example when it scopes over Associated Motion, only the Causative allomorph [-r] (bound to occurring immediately after stressed syllables) shows non-scopal orderings, whereas the allomorph [-ti] (which apparently lacks prosodic subcategorization) allows only for scopal ordering.

At the formal level, our analysis keeps most of the (we think, well-motivated) general assumptions of Caballero's original analysis, especially the organization of morphology in layers or strata (with different optimality-theoretic grammars) and the extensive use of prosodic subcategorization. We crucially depart in three aspects which allow for a more unified and modular analysis:

First, we assume a more modular overall relation between semantics and phonology in contrast to Caballero's approach where semantic, morphological and phonological constraints directly interact. In the model we use, scopal ordering is achieved strictly during morphological structure building. Non-scopal orderings are then exclusively derived in a second step by reordering of morphemes in phonological optimization.[2] This highlights the fact that all non-scopal orderings are ultimately motivated by phonological factors, but also allows for a more succinct separation of semantics and morphonology. Thus the fact that the Evidential in Rarámuri always has scope over all other relevant categories no matter what the actual ordering is can be attributed to a morphosemantic restriction which cannot be overwritten by phonological constraints due to modular organization: phonology can reorder the phonological content of affixes, but it cannot affect semantic interpretation.

Second, we use a unified approach to inward-looking and outward-looking subcategorization as virtual phonological structure (Lionnet & Rolle 2020). Caballero uses a subcategorization frame (in the form of a Generalized Alignment constraint) only for the Evidential, but assumes that contextual restrictions on length-alternating affixes are due to affix-specific morphotactic constraints. The unified subcategorization approach seems not only to be more parsimonious, it also allows us to stick to another important cornerstone of modularity, the Indirect Reference hypothesis which states that phonology doesn't have direct access to morphosyntactic and semantic information.

Third, we capture minimal morpheme-specific differences in morphophonological behavior by Gradient Symbolic Representations (GSR, Smolensky & Goldrick 2016). This can be nicely illustrated with the Applicative suffix /-ki/. As shown by table 1, /-ki/ only shows non-scopal orders with Causatives (in fact: the Causative /-r/) but not with respect to other affixes such as Associated Motion /-simi/. On the other hand, Causative /-ti/ shows non-scopal orderings for most of the relevant affixes. In an intuitive sense, the linearization patterns of /-ki/ are stronger than the ones for /-ti/. Gradient Symbolic Representations allow for a direct implementation of this intuition. Phonological representations such as precedence relations may have different strength (activation) and contrast therefore in the evaluation of phonological constraints. Conversely, the fact that Causative /-r/ may trigger reordering of Applicative /-ki/, but Associated Motion /-si/ (subcategorizing for a syllable to its right) may not can be captured by gradient subcategorizations of different strength since subcategorization is (virtual) phonological structure (see above). Finally, we also formalize length-alternations in suffixes (as for /-si(mi)/ and /-na(le)/) by representing the second syllables of these morphemes as weak phonological structure in line with Zimmermann's (2019) general GSR approach to ghost segments. Assigning a single underlying form to these affixes allows to capture that they always result in minimally bisyllabic complexes, a generalization which is lost if they are analyzed as suppletive

[2] See Gleim, Müller & Privizentseva (2023); Kalin & Rolle (2024) for independent evidence that 'misplaced' affixes result from a two-step process of concatenation and subsequent reordering.

allomorphs as in Caballero (2008).[3]

2 Theoretical Assumptions

Our analysis is based on three theoretical mechanisms which we will introduce in turn:

- Stratal Optimality Theory
- Subcategorization as Virtual Phonological Structure
- Gradient Symbolic Representations

2.1 Stratal Optimality Theory

With Caballero (2008), we assume that the morphophonology of Rarámuri is organized in different layers characterized by different affixes and different rankings of optimality-theoretic constraints. Whereas Caballero doesn't commit to a specific theoretical approach of this type (see Caballero 2008:3+4), we will implement this intuition by using Stratal Optimality Theory (Kiparsky 2000; Bermúdez-Otero 2018). (6) shows the suffix layers Caballero posits for Rarámuri, the phonological processes which characterize them and the assignment of strata in our analysis. Grey shading indicates the suffix classes participating in variable affix ordering, "CL" stands for Compensatory Lengthening:

(6) *Suffix layers according to Caballero (2010:168-171)*

<table>
<tr><td></td><td>S1</td><td>S2</td><td>S3</td><td>S4</td><td>S5</td><td>S6</td><td>S7</td><td>S8</td><td>S9</td><td>S10</td><td>S11</td><td>S12</td></tr>
<tr><td></td><td>INCH</td><td>TR</td><td>APP</td><td>CAUS</td><td>APP</td><td>DES</td><td>MOT</td><td>EV</td><td>voice ASP</td><td>TAM</td><td>TAM</td><td>SUB</td></tr>
<tr><td colspan="4"></td><td>ti / ri</td><td>ki</td><td>nale</td><td>simi</td><td>cane</td><td colspan="4"></td></tr>
<tr><td>Inner stem</td><td colspan="2">Derived stem</td><td colspan="3">Syntactic stem</td><td colspan="3">Aspectual stem</td><td colspan="3">Finite verb</td><td>Sub-ordi-nate verb</td></tr>
<tr><td>Haplo-logy</td><td colspan="12"></td></tr>
<tr><td>CL</td><td colspan="12"></td></tr>
<tr><td colspan="3">Imperative stress shift</td><td colspan="10"></td></tr>
<tr><td colspan="3">Passive-triggered lengthening</td><td colspan="10"></td></tr>
<tr><td colspan="9">Rounding harmony</td><td colspan="4"></td></tr>
</table>

Our reanalysis:

Root Level	Stem Level	Word Level

Merging Caballero's Syntactic and Aspectual Stem into a single Stem Level is the obvious choice in a Stratal-OT account since these domains do not differ in any of their phonological processes. On the other hand, variable affix order is found in both (and across both) domains. In our analysis this restriction follows naturally by assuming that only the constraint ranking at the Stem Level in principle sanctions affix reordering. Given the incremental architecture of Stratal OT, this directly predicts that Word-Level affixes remain

[3] Caballero (2022) also acknowledges informally that the behavior of these affixes is templatic, based on a single underlying form, and should not be analyzed as suppletive allomorphy. Our reanalysis here implements this intuition.

unaffected by reordering because they are only merged after Stem-Level evaluation. Root-Level affixes are immune to morpheme reordering due to another cornerstone of Stratal OT and related frameworks, Bracket Erasure (Pesetsky 1979; Kiparsky 1982; Orgun & Inkelas 2002; Bermúdez-Otero 2012) which makes identification of morphemic composition (and hence a fortiori changes in morphemic composition such as reordering) impossible to later strata such as the Stem Level. Note also that Caballero doesn't provide any explicit evidence that Haplology and Compensatory Lengthening cannot apply in her Derived Stem domain. It appears that the few affixes she assigns to this layer simply do not have the necessary phonological shapes to create the phonological environments for these processes. Thus the Null hypothesis in a stratal analysis seems to be that Inner Stem and Derived Stem constitute just a single stratum which we will call Root Level (see Clark 1990; Trommer 2011; Benz 2017 for related proposals).

With Bermúdez-Otero (2018) (and pace Kiparsky 2000, 2023) we assume that all strata are internally non-cyclic. Optionality is derived, as in Caballero's analysis, by the assumption that languages (and strata) might impose only partial rankings on the universal set of OT-constraints. Any given evaluation will then choose arbitrarily a complete ranking which is compatible with this partial 'master' ranking.

Along with Stratal, OT we will assume the restrictive modular overall architecture of the grammar of Bermúdez-Otero (2012), especially his adoption of the *Indirect Reference Hypothesis* – phonological rules and constraints do not have direct access to morphosyntactic structure and substance. For us this is crucial since in our analysis phonology reorders morphological entities (affixes). The framework we will use to implement Indirect Reference is the Coloring approach familiar from Colored Containment Theory which we import here into standard Correspondence Theory (McCarthy & Prince 1995; Kager 1999).[4]

The central idea of coloring is the assumption that at the transition from morphosyntax to phonology, all specific information about single morphemes (e.g., features like 1st person, plural, or the specific information identifying a root like *go*) is replaced by a set of arbitrary colors, resulting in a morpheme-level implementation of Indirect Reference. A useful analogy for this process is anonymization in the context of a behavioral experiment, where subjects get assigned arbitrary labels such as *A* and *B*. This still allows for retracing internal identity (e.g., that subject *B* reacted in the same ways to tasks 1 and 2 of the experiment), but makes it impossible to access individual data like name, or height. Similarly by Coloring all phonological material belonging to a particular morpheme M is assigned the same arbitrary color C, whose only substantial property is that it is different from the colors assigned to other morphemes and to colorless epenthetic material.

Trommer (2022) describes the role of coloring in restricting the phonology-morphology interface by the declarative principle in (7):

(7) *Color Map Hypothesis: The only morphological information visible to phonology are presence and difference of morphological color*

Put derivationally, all morphological information is deleted after Color Assignment and before phonological evaluation. Thus, OT-constraints may refer to whether two phonological elements are tautomorphemic or not, but cannot invoke specific colors, i.e., particular morphemes. Crucially, this results in a proper subset of the ways constraints may access morphological structure compared to more liberal approaches allowing for morpheme-specific ('indexed') constraints (Prince & Smolensky 1993; Pater 2007). To cite just one example: there can be general alignment constraints for *all* morpheme boundaries in a language (e.g., aligning them to syllable boundaries, but not morpheme-specific alignment-constraints, as for the Tagalog *um*-infix (Kager 1999:115+122).

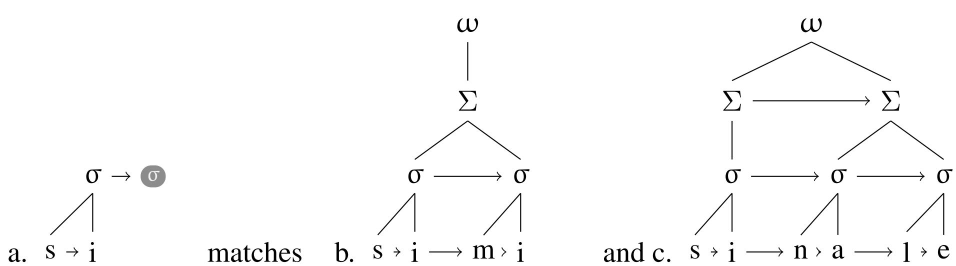
[4] Containment theory doesn't allow for reordering segments (see Moskal 2009; Zimmermann 2009), and a fortiori entire affixes, and is thus incompatible with the approach here which captures non-canonical ordering of affixes as dislocation in the phonology.

2.2 Subcategorization as Virtual Phonological Structure

Recall from section 1 that under our analysis, phonological subcategorization is a crucial building block in accounting for morpheme-specific behavior in Rarámuri affix ordering. Whereas phonological subcategorization is well-established in accounts of a broad spectrum of morphophonological phenomena (e.g., phonologically conditioned allomorphy, Paster 2006, infixation Yu 2002, ineffability Raffelsiefen 2004, prosodic smothering Bennett, Harizanov & Henderson 2018, and stress shifting, Bermúdez-Otero 2018), the formal nature of subcategorization is usually not spelled out in formal detail. Here we follow Lionnet & Rolle (2020) in assuming that subcategorization is virtual phonological structure which is not pronounced, but otherwise of the same type as standard phonological representations. More specifically we assume that for every substantive (pronounced) autosegmental tier, there is a corresponding virtual tier which may be matched to substantive phonology. Moreover, virtual and substantive units are integrated (via partial dominance and precedence relations).

This is illustrated in (8) with a simplified representation of the Rarámuri affix /-si(mi)/ which in our analysis subcategorizes for a syllable to its right. Virtual structure is marked here and throughout the paper by boxes with rounded corners (different shading and coloring of these boxes indicate different strengths of subcategorization as discussed in section 2.3). We assume directional autosegmental and prosodic representations where association is asymmetric hence amounts to dominance (for example syllables dominate segmental root nodes, segmental root nodes dominate features, etc.). For explicitness, we mark (immediate) precedence relations here by arrows, dominance is indicated in the usual way by association lines and vertical alignment (higher nodes dominate lower nodes). The substantial content of the suffix consists of the segments [s], [i] (where the first precedes the latter), and the syllable node dominating them.[5]

(8)



(shorthand: siσ)

Autosegmental representations are hence directed graphs where directionality corresponds to precedence and dominance. Matching can then defined as in (10) using the auxiliary notions in (9):

[5] Matching of subcategorization is a notion defined over single integrated graphs. Thus we actually presuppose graphs where (8-a) is merged with (8-b) and (8-c) thus that the s-, i-nodes and the σ-node dominating both occur only once and are overlayed. We decompose the graphs here in graphical representation because the σ-node precedes both a virtual σ-node and a substantive σ-node, which are not in a precedence relation. This makes it difficult to represent in graphical form. (8-a) of course is also the shape of the affix before it is merged and becomes part of more complex autosegmental representations.

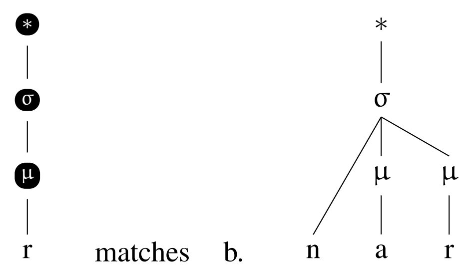
(9) *Auxiliary definitions*

A **substantial path**	through a graph G is a directed path in G which contains only substantial nodes
A **selectional path**	P through a graph G is a directed path in G which contains exactly one substantial node N N is either initial or final in P and all other nodes in P are selectional nodes
A **selectional subgraph**	S of a graph G is a subgraph of G which contains only selectional nodes, and is maximal (i.e., there is no edge connecting a node in S to a node which is not in S)

(10) *Definition of Matching*
A selectional subgraph S of a Graph G matches G iff
for every selectional path P from a node N of G to a node N' of S
there is a substantial path P' from N to a substantial node N''
such that Label(P[i]) = Label(P'[i])

(8) is a trivial case where the selectional path σ → σ matches substantial paths of the shape σ → σ since all labels of nodes are 'σ'. A slightly more complex case is shown in (11), the Causative suffix /-r/ which always occurs in the coda of a stressed syllable. We represent stress here simply as grid marks dominating syllable nodes (Liberman & Prince 1977; Prince 1983; Halle & Vergnaud 1987; Alderete 2001; Hagberg 2006; Revithiadou 2007). (11-b) contains three selectional paths ① μ → r, ② σ → μ → r and ③ * → σ → μ → r, which all have substantive paths in (11-b) with corresponding labels.

(11)

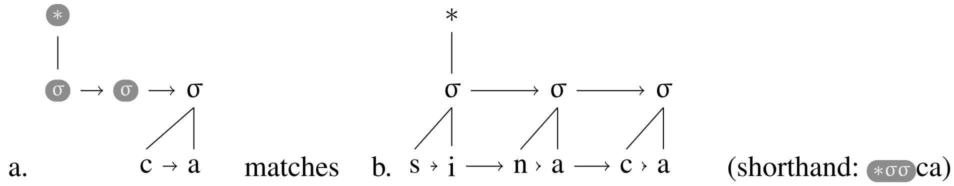


a. matches b. (shorthand: *σr)

(11-a) is a case of what Bennett et al. (2018) call *vertical* subcategorization where a morpheme is required to be dominated not preceded or followed by specific phonological structure as in *lateral* subcategorization exemplified by the Associated Motion suffix in 8. In section 3.2 we will see that the position of Causative /-r/ can always be captured by the statement that it is in coda of the stressed syllable (as encoded by the subcategorization frame in (11-a)), but there is no equivalent lateral subcategorization. For example, /-r/ does not always immediately follow the stressed vowel because it also may attach to a stressed syllable which already has a coda consonant.

In fact, under our definition of matching (and given that subcategorization has all properties of autosegmental graphs, precedence *and* dominance relations) there is no strict separation between vertical and lateral subcategorization. A subcategorization frame can contain both aspects as shown by the partial representation of the Evidential suffix /-can(e)/ shown in (12). /-can(e)/ selects for two preceding syllables the first of which bears accent:

(12)



(12-b) again contains three selectional paths ① σ → σ, ② σ → σ → σ and ③ * → σ → σ → σ, with corresponding paths.

The implementation of subcategorization as virtual structure has several advantages (see also Lionnet & Rolle 2020 on independent more specific arguments for a virtual structure account of subcategorization from the tonal morphophonology of Kuria):

First, it derives the general fact that subcategorization is phonologically local. Thus phonologically conditioned allomorphy is generally sensitive to phonological features at the same edge at which they are attached. For example the allomorphy in the English indefinite article between between *an* and *a* (*a pear* vs. *an apple*) is sensitive to the initial segment not the final segment of the word to which it is attached. *Second,* virtual structure allows for a more modular implementation of subcategorization. The standard OT implementation of prosodic subcategorization adopted by Caballero (2010) is via morpheme-specific alignment constraints (McCarthy & Prince 1993) violating Indirect Reference by granting phonology access to morphological information. Conversely, under the more traditional concept (see, e.g. Paster 2006) using subcategorization frames, morphology checks the compatibility of prosodic requirements before phonological computation. In contrast, in the virtual structure approach, no intermixture of phonology and morphology is necessary. Phonological computation simply evaluates phonological representations. *Third*, for our analysis here, a crucial advantage of the virtual structure approach is that subcategorization can be inherited across strata. This follows from the fact that in this implementation subcategorization – apart from being unpronounceable– is simply phonological structure which will be maintained at the transition from one stratum to the next as long as it is not deleted by specific phonological processes. More specifically, we assume that subcategorization requirements are deleted by the operation of *Subcategorization Discharge* defined in

(13) *Subcategorization Discharge*
If a selectional subgraph S of G matches G at the output of a stratum, S is removed from G

Thus subcategorization requirements will be inherited to subsequent strata if and only if they are still not satisfied.

2.3 Gradient Symbolic Representations

Gradient Symbolic Representations (Smolensky & Goldrick 2016; Rosen 2016; Zimmermann 2018, 2019, 2021; Hsu 2022) is a fundamentally new approach to the nature of linguistic representations where all linguistic primitives may have different activation levels $0 \leq A \leq 1$. Activation or ‘strength’ thus adds an additional distinctive dimension to grammatical units, in the case of phonology segments, features association lines, etc. A standard assumption of this approach is that output representations are only pronounced if they are fully activated (i.e., if their activity equals 1).

Strength of representations will be crucial for our analysis in three different domains.

First, for the representation of unstable (‘ghost’) segments. Thus several verbal affixes involved in variable affix ordering in Rarámuri surface in long and short versions. For example the Evidential suffix surfaces as [-cane] word-finally and before a small class of TAM suffixes, but is otherwise realized in its short form [-ca] (as assumed in (13)). We will interpret this as underlying segments of different strength: [c] and [a] are fully, but [n] and [e] only partially activated. Under our analysis this will mean that [ca] is realized in all contexts, but [ne] only if high-ranked phonological constraints enforce it. -cane. [n] and [e] are thus 'ghost segments' (see Zimmermann 2019 for independent crosslinguistic arguments to capture ghost segments more generally by Gradient Symbolic Representations).

Second, we suggest that linearization, i.e. immediate precedence relations between morphemes can also be of different strength. This in our analysis accounts for the fact that specific pairs of affixes resist reordering in contexts where combinations of other affixes with comparable shape (and the same stratal affiliation) undergo phonologically conditioned reordering. We assume that strength of underlying linearization for a given pair of morphemes is information stored by speakers as primitive lexical knowledge similar to the bigrams proposed by Ryan (2010). However, in contrast to Ryan-style bigrams, the linearization strength we assume here does not imply a preference for any specific morpheme ordering. It rather encodes the faithfulness of a pair of morphemes to its underlying order (i.e., the semantically motivated order). For example assume that the linearization strength for the combination of the Applicative affix /-ki/ and the Causative /-ti/ is 0.7. There will be underlying combinations of /-ki/ and /-ti/ where the Applicative has scope over the causative (i.e., /-ki/ linearly follows /-ti/) and other combinations where Causative has scope over the Applicative (/-ti/ linearly follows /-ki/) depending on the intentions of the speaker. Still both underlying ordering relations have the activation of 0.7.

Third, subcategorization specifications may be of different strength. In fact this follows already from our assumption that subcategorization consists of virtual phonological structure which is otherwise completely analogous to standard phonological representations. Since under the GSR approach, all phonological representations have gradient activations, this implies that it will also extend to virtual structure, i.e., to subcategorization. In our analysis, we will use different subcategorization strength to capture the fact that affixes which trigger reordering due to their phonological subcategorization might idiosyncratically differ in the extent to which their subcategorization affects the order of other morphemes.

Because the applications of strength in our analysis don't necessitate more than 3 different degrees of activation, we will abstract away from specific numerical values and simply refer to 'weak' ($0 \leq x < 3.\bar{3}$), 'medium' ($3.\bar{3} \leq x < 6.\bar{6}$) and 'strong' ($6.\bar{6} \leq x \leq 1$) activation. OT-constraints will also refer directly to strong, weak or intermediate-strength representations.

(14) illustrates our graphical representations for these three degrees of strength with three different affixes from our analysis. Weak subcategorization is indicated by black print in white boxes as in (14-a) for a syllable to the right, strong subcategorization by white print in boxes with black shading (in (14-c) for a syllable to the left), and medium-strength subcategorization by white print in boxes shaded in dark grey (14-b).Weak substantive representations are marked by grey print, as for mi in (14-b), and ∗le in (14-a) ('∗' is an – also weak – accent grid mark, see section 3.4 for discussion). Strong substantive representations have no special marking, hence are simply indicated by standard black print ('na' in (14-a), 'si' in (14-b) and 'r' in (14-c)):

(14) *Strength of subcategorization*

a. Strong 1st σ, weak 2nd σ, weak subcategorization: -na∗leσ (Desiderative)

b. Strong 1st σ, weak 2nd σ, medium subcategorization: -simiσ (Associated Motion)

c. Strong subcategorization and segment -∗σr (Causative)
σ (Associated Motion)

The same notation will also be used for different degrees of linearization/precedence (weak: →, middle: →, strong: →), and the constraints Template Satisfaction and Linearity. Thus Linearity will only penalize reordering for two morphemes if their underlying linearization is weak, Linearity if it is of intermediate strength, and Linearity if it is strong.

3 Analysis

3.1 Setting the Stage: Left-dislocated Evidential

We introduce the basics of our analysis by a reimplementation of Caballero's account of the relative order of Evidential and Desiderative. The major difference is our assumption that prosodically conditioned morpheme ordering is computed strictly after morphology, in phonological evaluation in every stratum:

(15) ⟶ Morphology: Affixation creates strictly scopal order ⟶ Phonology: Affix reordering contingent on phonological constraints and prosodic subcategorization

Let us now turn to the central generalizations about the relative order of both affixes. Note first that, although both surface orderings of Desiderative and Evidential occur, the interpretation is always one where the Evidential has scope over the Desiderative. This is illustrated by the examples in (16) and (17). In both examples, the Evidential scopes over the Desiderative; thus, for example, the reverse scope, 'it wants to sound like they want to sneeze' for (17) is infelicitous. These examples also illustrate the extended glossing we will provide for examples in the following, where the second line of every example (indicated on both sides by the delimiter '|') shows the Stem-Level representation of the form. The main difference to the underlying form is that length-alternating suffixes such as /-na(le)/ will assume a specific short (as with [-na] in (16), or long variant (as with /-na(le)/ in (17)). The main difference to the surface form is that post-tonic syncope (vowel deletion) which in Rarámuri applies to many unstressed vowels is not applied because this is arguably a Word-Level process. Word-Level affixes such as Progressive /-a/ in (16) are simply omitted from the Stem-Level representation.

(16) *Compositional order: Ev $\rhd$ Des $\wedge$ Ev $\succ$ Des*
nakó-**n**-**can**-a
|nakó-**na**-**cane**|
/nako-**na(le)**-**ca(ne)**-a/
fist.fight-DES-EV-PROG
'It sounds like they want to fist fight' (2010:183:28-a)

(17) *Non-compositional order with left-dislocated Evidential: Ev $\rhd$ Des $\wedge$ Des $\succ$ Ev*
atís-**ca**-**nare**
|atísi-**ca**-**nale**|/
/atisi-**ca(ne)**-**na(le)**/
sneeze-EV-DES
'It sounds like they want to sneeze' (2010:184:29-a)

(16) and (17) are also representative in illustrating the second central generalization on the order of Desiderative and Evidential: their relative position is phonologically predictable. As observed by Caballero (2010), non-scopal ordering of /-na(le)/ and Evidential /-ca(ne)/ as in (17) only takes place if (and only if) the base (i.e., the root and the affixes preceding both suffixes) has penultimate stress (in (17): [atísi]). If the base has final stress such as [nakó] in (16), or stress falls on /-na(le)/, scopal order obtains.

A closely correlated observation is that in combinations with Desiderative /-na(le)/, Evidential /-ca(ne)/ is always preceded by the sequence of a stressed and an unstressed syllable, either because it directly follows a base with penultimate stress as in (17-a) or because it is preceded by the long stressed allomorph of the

Desiderative [-nále] (17-b), or because it follows the short/unstressed allomorph of the Desiderative ([-na]) after a base with final stress (17-c). The central insight of Caballero is that this ultimately motivates the non-compositional orders: the Evidential suffix carries a prosodic subcategorization frame requiring this configuration. (18-a) shows this in the notation used by Caballero, (18-b) is the notation using virtual structure we assume here:

(18) Subcategorization of Evidential /-ca(ne)/ (adapted from Caballero 2010:185,Caballero 2008:350)
a. $[(\sigma\sigma)_{\text{Ft}}$ -cane$]_{\text{Evidential}}$ b. $*\sigma\sigma$cane

(19) atísi-nare-$*\sigma\sigma$cane – Phonology → atísi-$*\sigma\sigma$cane-nare

In our analysis, dislocation of affixes is crucially determined by the interaction of the two constraints defined in (20). LINEARITY is the standard faithfulness constraint penalizing changes in linear order (see, e.g., McCarthy & Prince 1995; Kager 1999; Horwood 2002). TEMPLATE SATISFACTION is the constraint we will use to require fulfillment of subcategorization requirements (see (9) and (10) above for definitions of the notions *subgraph* and *matching*, and Zec 2005; Trommer 2015; Bennett et al. 2018 for similar constraints):

(20) *Central constraints governing affix dislocation*

a. LINEARITY	Assign $*$ to every pair of output segments (S1,S2) whose linearization differs from that of the corresponding input segments (S1',S2')
b. TEMPLATE SATISFACTION	Assign $*$ to every selectional subgraph of a phonological representation R which doesn't match R

As laid out in section 2.3, these constraints have specific avatars sensitive to the strength of phonological objects they are applying to. In the case at hand, the leftwards subcategorization of /-ca(ne)/ has intermediate strength, and the linearization of Desiderative and Evidential is weak. Thus (21) and (22) show how the ranking of TEMPLATE SATISFACTION above LINEARITY derives (16) and (17). In (21), the output involves only choosing the short variant of /-na(le)/, but no reordering since this already satisfies the template of /-ca(ne)/. On the other hand, in (22), the distance between /-ca(ne)/ and the word stress in the compositional order (22-a) is too big (two syllables instead of one), hence incurs a violation of TEMPLATE SATISFACTION, and consequently reversal of the suffixes is tolerated at the cost of violating LINEARITY (22-b):

(21) *Compositional order* – **Input:** nakó-nare-→-$*\sigma\sigma$cane

	TEMPLATE SATISFACTION	LINEARITY
☞ a. nakó-na-$*\sigma\sigma$cane		
b. nakó-$*\sigma\sigma$ca-nare	*!	*

(22) *Non-compositional order* – **Input:** atísi-nale-→-$*\sigma\sigma$cane

	TEMPLATE SATISFACTION	LINEARITY
a. atísi-na-$*\sigma\sigma$cane	*!	
☞ b. atísi-$*\sigma\sigma$ca-nale		*

It is important to keep in mind that in our analysis cases of reordering like in (22) take place in the phonological not in the morphological part of the grammar, hence it involves reordering of phonological primitives, more specifically: segments. Still the Rarámuri data have not the characteristics of metathesis or infixation, but always involve reordering of entire affixes. This requires to ensure that affixes of a given morpheme either dislocate as a unit or don't reorder at all. We derive this by the two undominated constraints in (23):[6]

(23)	a. MORPHOLOGICAL CONTIGUITY	The portions of the output belonging to the same morpheme form contiguous strings (Landman 2002:1)
	b. HOMOMORPHEMIC LINEARITY	Homomorphemic precedence relations in the input are preserved in the output (Horwood 2002:5)

(24) shows the effects of these constraints in an extended version of the evaluation in (22) (underlining indicates the portions of the out put strings which have been reordered). In (24-b), /-ca(ne)/'s subcategorization is satisfied by reordering parts of the root ([si] and [tí]) which is excluded by HOMOMORPHEMIC LINEARITY since all involved segments are part of the same morpheme. In (24-c) the sequence [si] is shifted to the end of the word. This form doesn't violate form HOMOMORPHEMIC LINEARITY (the segments of [si] still follow the homomorphemic segments of [atí], as in the input), but [atí] and [si] don't form a contiguous string and thus lead to a fatal violation of MORPHOLOGICAL CONTIGUITY. The same holds for (24-d) where /-ca(ne)/ is split up by moving [ca] to the left and leaving [ne] behind:

(24) *Non-compositional order* – **Input:** atísi-nale-→-∗σσcane

	HOMOMORPHEMIC LINEARITY	MORPHOLOGICAL CONTIGUITY	TEMPLATE SATISFACTION	LINEARITY
a. atísi-na-∗σσcane			*!	
b. asití-na-∗σσcane	*!			
c. atí-na-∗σσca-si		*!		*
d. atísi-∗σσca-na-ne		*!		*
☞ e. atísi-∗σσca-nale				*

Since MORPHOLOGICAL CONTIGUITY and HOMOMORPHEMIC LINEARITY are never violated in Rarámuri, we will usually omit them from tableaux in the following analysis. As a further simplification based on this restriction we will also indicate LINEARITY violations as if they would refer to morphemes not to segments.

An immediate prediction of the ranking shown in (24) is that the subcategorization requirement of /-ca(ne)/ *can* be violated if there is no repair option satisfying by reordering of affixes. This is confirmed by the data in (25) where /-ca(ne)/ is the only suffix and appears immediately after the stressed syllable (see (67) for a case where /-ca(ne)/ is separated by more than one syllable from the stressed syllable):

(25) *Simple affixation /-ca(ne)/ right-adjacent to stressed syllable*

kusú-cani	'it sounds like animal noise' (2008:36:23-d)
wikará-cane	'it sounds like singing' (2008:296:11-c)
toré-cani	'it sounds like cackling' (2008:298:13-i)
osí-can-a	'it sounds like writing' (2008:36:23-e)
misú-cun-a	'It sounds like they are catching (mice)' (2008:161:67-e)
rosowá-cin-o	'It sounds like coughing' (2008:290:5-a)

[6] We have slightly simplified the formulations of both constraints. Landman actually calls the constraint we adopt here MORPHOLOGICAL OUTPUT CONTIGUITY since she also argues for a sister CONTIGUITY constraint based on input strings.

(26) illustrates why the violations in (25) are unavoidable under our analysis. Simple reordering of /-ca(ne)/ and the root (26-b) would also not fulfill TEMPLATE SATISFACTION, and leads to additional violations of LINEARITY. All other conceivable rearrangements of segments would either violate MORPHOLOGICAL CONTIGUITY (26-c) or TEMPLATE SATISFACTION (26-d):[7]

(26) *Output violation of* TEMPLATE SATISFACTION – **Input:** a.

	HOMOMORPHEMIC LINEARITY	MORPHOLOGICAL CONTIGUITY	TEMPLATE SATISFACTION	LINEARITY
☞ a. toré-*σσcane			*	
b. *σσcane-toré			*	*!
c. <u>ré</u>to-*σσcane	*!			*
d. toré-<u>ne</u>-*σσca		*!		*

Note finally that the forms in (16) and (17) provide an immediate argument for strata. The generalization that Evidential /-ca(ne)/ is right-adjacent to the sequence σ́σ is true for the Stem-Level representation as in |atísi-**ca-nale**|, but not for the surface form [atís-**ca-nare**], which has undergone syncope thus that /-ca(ne)/ now immediately follows the stressed syllable. Since syncope of unstressed vowels is a variable, but otherwise very general process in the language which doesn't distinguish different morphological layers, it is natural to assume that it is a Word-Level process. On the other hand, morpheme reordering only occurs in the domain we identify with the Stem Level. Thus the stratal architecture correctly predicts the type of opacity observed in these data.

3.2 Extending the Subcategorization Analysis: Left-dislocated Causative

Up to this point, we have basically reimplemented Caballero's insights on the morphophonological conditioning of Mirror-Priciple violations in the order of Evidential and Desiderative. In this section, we will argue that the same approach accounts for non-scopal orderings involving left-dislocation of Causative suffixes.

Note first that the Causative in many forms cooccurs with the Associated Motion, Desiderative and Applicative suffixes in a compositional reading. With Desiderative (27) and Associated Motion (28), this results in two possible orders with corresponding scope. The examples also illustrate two of the allomorphs of the Causative, /-ti/ and /-r/:

(27) *Compositional orders of Causative and Desiderative*

a. CAUS ▷ DES

mi=ni	awi-**nár**-**ti**-ma	orá
|mi=ni	awi-**nále**-**ti**	orá|
/mi=ni	awi-**nále**-**ti**-ma	orá/
2SG.ACC=1SG.NOM	dance-**DES**-**CAUS**-FUT.SG	

'I will make you want to dance' (2010:179:22)

b. DES ▷ CAUS

[7] We implicitly make here the simplifying assumption that stress is an inherent lexical property of the word modulo the Evidential suffix. In fact stress depends in a complex way on factors such as underlying accent and length of roots and accent specifications of affixes. Data like the ones in (25) thus also imply that the constraints responsible for stress assignment outrank TEMPLATE SATISFACTION. We will illustrate the direct interaction of constraints on stress and on affix linearization in section 3.4 below.

nihé mi awí-**r**-**nare**
|nehé mi awi-**r**-**nale**|
/nehé mi awi-**r**-**nale**/
1SG.NOM 2SG.ACC dance-**CAUS**-**DES**
'I want to make you dance' (2010:180:23)

(28) *Compositional orders of Causative and Associated Motion*

a. MOT ▷ CAUS
ma=ti pocí-**ti**-**si**-a
|ma=ti pocí-**ti**-**si**|
/ma=ti pocí-**ti**-**si(mi)**-a
2SG.ACC=1SG.NOM jump-**CAUS**-**MOT**-FUT.SG
'Shall we go along making them jump?' (2010:177:30)

b. CAUS ▷ MOT
ma=ni mi wikará-**s**-**ti**-ma
|ma=ni mi wikará-**si**-**ti**|
/ma=ni mi wikará-**si(mi)**-**ti**-ma/
already=1SG.NOM 2SG.ACC sing-**MOT**-**CAUS**
'I'll make you go along singing' (2010:178:21)

The Applicative is more restricted. As shown by Caballero, the interpretation of forms with the Applicative is always one where the other relevant categories have scope over the Applicative. In the form in (29) this is transparently reflected in affix order:

(29) *Compositional order of Causative and Applicative*:CAUS ▷ APP
jéni dúlse íw-**ki**-**ti**-ri jadíra
|jéni dúlse íbi-**ki**-**ti**-ri jadíra|
/jéni dúlse íbi-**ki**-**ti**-ri jadíra/
Yeni candy bring.APPL-**APP**- **CAUS**-IMP.SG Yadira
'Make Jeni bring candy for Yadira' (2010:186:31-c)

Here we are concerned with orderings where the Causative has scope over other categories, but on the surface occurs more inside, resulting in a Mirror-Principle violation as shown in (30) for the Desiderative and Associated Motion:

(30) *Non-compositional order of Causative and Associated Motion*: CAUS ▷ MOT
mi=n piwá-**r**-**si**-mo rá
|mi=ni pewá-**r**-**si** olá|
/mi=ni pewa-**r**-**si(mi)**-ma olá/
2SG.ACC=1SG.NOM smoke-**CAUS**-**MOT** CER
'I'll make you go along smoking' (2010:178:21)

(31) *Non-compositional order of Causative and Desiderative*

a. CAUS ▷ DES *(non-compositional order)*
rarí-**r**-**niri**-si
|rarí-**r**-**nale**|
/rari-**r**-**na(le)**-si/
buy-**CAUS**-**DES**-IMP.PL
'Make her want to buy soda!' (2010:198:51-h)

b. CAUS ▷ DES *(non-compositional order)*
koʔá-**r**-**ti**-**ni**-sa
|koʔá-**r**-**ti**-**na**|
/koʔa-**r**-**ti**-**na(le)**-sa/
eat-**CAUS**-**CAUS**-**DES**-IMP
'Let's make her want to eat!' (2010:187)

(32) *Non-compositional order of Causative and Applicative* CAUS ▷ APP

tamí	noké-**r**-**ti**-**ki**-ri
|tamí	noké-**r**-**ti**-**ki**-ri|
/tamí	noké-**r**-**ti**-**ki**-ri/
1SG.ACC	move.APPL-**CAUS**-**CAUS**-**APP**-IMP.SG

'Make him move it for me' (2010:186:32-b)

Our novel proposal for these non-harmonic forms is that they are related to a special property of the Causative allomorph /-r/ which, without exceptions, appears immediately after the stressed vowel. This generalization can be seen in the examples in (32), but it holds also for compositional forms as in (27b) and all other forms with the Causative (e.g., [osá-r-ma] write/read-CAUS-FUT:SG, 2008:105:8-g and [sukú-r-ki] scratch-CAUS-PST:1, 2008:188:20-h). Whenever the surface form is [-r], it is after the stressed vowel and whenever the Causative doesn't occur after the stressed vowel, an other allomorph of Causative surfaces. The tableaux in (33) and (34) show the gist of the analysis. /-r/ moves inside associated motion /-si/ to satisfy its subcategorization (33), but /-ti/ stays in its original position (34) since this allomorph lack any specific subcategorization (see sections 3.5 and 3.6 for evidence that the subcategorization of /-r/ is strong):

(33) *Non-compositional order by subcategorization:* **Input:** piwá-si$_{\text{MOT}}$-→-*σr$_{\text{CAUS}}$

	TEMPLATE SATISFACTION	LIN
a. piwá-si-*σr	*!	
☞ b. piwá-*σr-si		*

(34) *No subcategorization: compositional order* - ti$_{\text{CAUS}}$ **Input:** wikará-si$_{\text{MOT}}$-→-ti$_{\text{CAUS}}$

	TEMPLATE SATISFACTION	LIN
☞ a. wikará-si-ti		
b. wikará-ti-si		*!

There are several complications connected to allomorphy and multiple exponence of the Causative. The Causative in Rarámuri can be expressed by 4 different surface realizations: as [-ti] as [-ri] as [-r] and by the combination of [-t] and [-ri] ([-r-ti]). The choice of these variants is partially lexeme-specific, thus the selection between [-ti] vs. [-ri] seems to be dependent on specific lexical roots (2008:240). But there are also phonological factors at play: [-r] (and [-r-ti]) only occurs immediately after a stressed vowel. Our interpretation of this situation is as follows: There are two listed allomorphs of the Causative /-r/ and /-ti/. (which may be combined into /-r-ti/). [-ri] is a surface variant of /-ti/. Specific roots impose rhoticity on a following /t/-initial affix by a floating [+rhotic] feature. This changes /-ti/ to [-ri].[8]

A striking generalization about multiple exponence of Causative by /-r/ and /-ti/ is that they are always adjacent, hence occur together immediately after the stressed vowel even if this violates the mirror principle. Thus in (35) and (36) not only /-r/, but also /-ti/ occurs counterscopally inside of /-ki/ and /-na/:

(35) *Non-compositional order of Causative and Desiderative* CAUS ▷ APP

mi=n	tamí	kocí	ubá-**r-ti-ki**-ma
|mi=n	tamí	kocí	ubá-**r-ti-ki**|
/mi=n	tamí	kocí	uba-**r-ti-ki**-ma/
2SG.ACC=1SG.NOM	1SG.ACC	dog	bathe-**CAUS-CAUS-APP**-FUT.SG

'I'll make you bathe the dog for me' (32-c)

(36) *Non-compositional order of Causative and Desiderative* CAUS ▷ DES

nihé	mi	sú-**r-ti-na**-ma
|nihé	mi	sú-**r-ti-na(∗le)**|
/nihé	mi	sú-**r-ti-na(∗le)**-ma/
1SG.NOM	2SG.ACC	sew-**CAUS-CAUS-DES**-FUT.SG

'I'll make you want to sew' (32-c)

This directly follows from our analysis under the natural assumption that the two Causative allomorphs have the same morphological color. MORPHOLOGICAL CONTIGUITY will then ensure that they cannot be separated by other morphemic material:

(37) *Non-compositional order; strong subcategorization*: **Input:** ubá-ki$_{\text{APP}}$-(→)-(∗σ)r$_{\text{CAUS}}$-ti$_{\text{CAUS}}$

	MORPHOLOGICAL CONTIGUITY	TEMPLATE SATISFACTION	LINEARITY
a. ubá-ki-(∗σ)r-ti		*!	
b. ubá-r-ki-ti	*!		*
☞ c. ubá-r-ti-ki			**

A final complication is that there are a handful of examples where the Causative appears inside of the Applicative, but is expressed on the surface only by [-ti]:

[8] Our interpretation of the Causative allomorphy differs slightly from the one suggested by Caballero who posits two basic allomorphs /-ti/ and /-ri/, and derives [-r] by posttonic syncope from /-ri/. Both accounts are empirically equivalent, but Caballero's analysis doesn't allow to link the distribution of non-compositional Causative orders to the specific distribution of the [r]-allomorph. The approach suggested here has a further advantage in a stratal account: it makes it possible to formalize the fact that [-ti] can cooccur with [-r], but not with [-ri] (there are no surface forms expressing Causative as *[-ri-ti]). Caballero explains this by the fact that [-r] by lacking a vowel is phonologically too weak as an exponent, and hence licenses insertion of a further Causative morph. However posttonic syncope in Rarámuri is clearly a Word-Level, not a Stem-Level process (it may apply to all suffixes as long as they are not in word-final position), whereas alternative-order suffixes such as the Causative are Stem-Level. Whether we accept Caballero's approach, or implement the cooccurence restrictions of Causatives by more stipulative morphological rules, Stem-Level insertion of /-ti/ would have to be sensitive to the fact that /-ri/ is syncopated at the Word-Level, a stratal paradox.

(38) *Exceptional non-compositional ordering without* [-r]

a. CAUS ▷ APP *(non-compositional order)*

tamí	ko=mi	oʔpés-**ti**-**ki**-ma	aré	ba
|tamí	ko=mi	oʔpési-**ti**-**ki**	aré	ba|
/tamí	ko=mi	oʔpési-**ti**-**ki**-ma	alé	ba/
1SG.ACC	EMPH=2SG.NOM	vomit-**CAUS**-**APP**-FUT.SG	DUB	CL

'You'll make him throw up on me' (2010:186:32-a)

However, these exceptions are not random. They occur only in forms where [-ti] is in a specific prosodic configuration: It separated by exactly one syllable from the stressed vowel at the Stem Level, which is elided on the surface. We take this as evidence that these exceptional forms have underlyingly not /-ti/, but /-r-ti/, obscured by phonological opacity across strata. Thus after /-r-ti/ attaches to the bisyllabic root /pési/, which bears initial stress, /-r/'s subcategorization for integration into a stressed syllable causes deletion of the unstressed vowel of the stem, yielding (pésr)$_\sigma$. (Infixation, as in **pé-rsi*, is independently excluded by MORPHOLOGICAL CONTIGUITY). The resulting [sr]-cluster is tolerated at the Stem Level but repaired by deletion at the Word Level. The derivation is sketched in (39).

(39)	oʔ(pési)-ki-r-ti	Stem Level Morphology
	→ oʔ(pésr)$_\sigma$-ti-ki	Stem Level Phonology
	→ oʔ(pésr)$_\sigma$-ti-ki-ma	Word Level Morphology
	→ oʔ(pés)$_\sigma$-ti-ki-ma	Word Level Phonology

The tableau in (40) shows how affix ordering for this example is computed at the Stem Level. We assume that MAX V penalizing deletion of vowels is ranked immediately below TSAT and above all other TEMPLATE SATISFACTION and LINEARITY constraints. As a consequence vowel deletion will only obtained to satisfy strong (not intermediate-strength or weak) subcategorization, and even then only if morpheme reordering would not repair the TSAT violation as in our example where pési is a undecomposable root. In fact, as shown in (40), template satisfaction here is satisfied not by (iterative) vowel deletion alone as in (40-c), but by the combination of affix reordering and simple vowel deletion as in (40-e).

(40) *Non-compositional order; strong subcategorization* **Input:** pési-ki$_{\text{APP}}$-→-*σr$_{\text{CAUS}}$-ti$_{\text{CAUS}}$

	MORPHOLOGICAL CONTIGUITY	TEMPLATE SATISFACTION	MAX V	LINEARITY
a. oʔpési-ki-*σr-ti		*!		
b. oʔpési-r-ti-ki		*!		*
c. oʔpés-k-*σr-ti			**!	
d. oʔpés-r-ki-ti	*!		*	*
☞ e. oʔpés-r-ti-ki			*	*

Thus, our analysis predicts that Causative reordering without /-r/ is only possible with roots that have nonfinal stress.

3.3 Left Dislocation of Length-alternating Suffixes: Associated Motion

Rarámuri has several suffixes which alternate predictably between a bisyllabic and a monosyllabic variant (lacking the second syllable) depending on their position in the stem:

(41)

	Long variant	*Short variant*
Associated Motion	-simi	-si
Desiderative	-nale	-na
Evidential	-cane	-ca

We will discuss the pattern here on the basis of the Associated Motion suffix /-si(mi)/. The monosyllabic variant appears if the suffix is word-final (42-a), and the short variant appears otherwise (42-b,c) (in (42-c) also posttonic syncope applies):

(42) *Long and short allomorphs of Associated Motion /-si(mi)/*

a. *Long allomorph word-finally*
nári-**simi**
|nári-**si(mi)**|
/nári-**si(mi)**/
ask-**MOT**
'they go along asking' (2008:289:3-e)

b. *Short allomorph word-internally*
nár-**si**-mo
|nári-**si(mi)**|
/nári-**si(mi)**-mo/
ask-**MOT**-FUT.SG
'she will go along asking' (2008:289:3-f)

c. *Short allomorph word-internally*
wikará-**s**-ka
|wikará-**si(mi)**|
/wikará-**si(mi)**-ka/
sing-**MOT**-GER
'going along singing' (2008:296:11-f)

Caballero shows that this distribution does not follow from a general alternation in the language. Whereas Rarámuri has a pervasive process of syncope, this deletes only vowels, never consonants. Polysyllabic roots don't show the same alternations. Finally, there is a bisyllabic suffix which can in principle show up untruncated even if it is followed by other stem-level affixes (Desiderative /-na(le)/, see section 3.4).
However, apart from the length alternation, MOT also has a special behavior in linear ordering. If Associated Motion has scope over a Causative not involving /-r/, /-si(mi)/ may occur either outside of Causative /-ti/ according to scope as in (43) or in non-compositional left-dislocated order (44). Caballero describes this as a pattern of free variation. Thus in principle also [korú-**si**-**ti**] in (43) and [sú-**ti**-**simi**-ma] in (44) are possible:

(43) MOT ▷ CAUS: *Compositional order*

we	tamí	korú-**ti**-**simi**
|we	tamí	korú-**ti**-**simi**|
/we	tamí	korú-**ti**-**si(mi)**/
int	1SG.ACC	feel.like.eating-**CAUS**-**MOT**

'They are going along making me want to eat' (2010:178:20-d)

(44) MOT ▷ CAUS: *Non-compositional order*

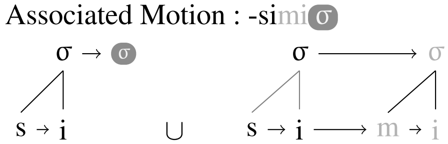
nihé	mi	sú-**s**-**ti**-ma	sipúci
|nehé	mi	sú-**si**-**ti**-ma	sipúca|
/nehé	mi	sú-**si(mi)**-**ti**-ma	sipúca/
1SG.NOM	2SG.ACC	sew-**MOT**-**CAUS**-FUT.SG	skirt

'I will go along making you sew the skirt' (2010:188:34-d)

For Caballero, the possibility of non-compositional ordering and the length alternation of /-si(mi)/ are unrelated facts. In contrast, we suggest that they follow from a single generalization: Associative Motion /-si/ is always followed by a syllable to its right. This is either achieved by a following independent suffix or by choosing the long form of the suffix. In our approach, the reasons triggering this alternation can be directly modeled by subcategorization and gradient representations. /-si/ subcategorizes for a syllable on its right. At the same time, only the segments /-si/ of the affix have full activation /m/ and /i/ are only weakly activated and will therefore only be realized if necessary to satisfy the subcategorization requirement of the affix. (45) shows the representation of the affix in abbreviated forms (45-a) and in the form of two partial hierarchical representations with the structures following /-si/ on the substantial and the selectional tier (45-b):

(45) *Representation of /-si(mi)/*

a. Associated Motion : -simiσ

b. 

We will first discuss our approach to the general length alternation which follows from the interplay of TEMPLATE SATISFACTION and a general faithfulness constraint against increasing the activation of reprsentations:

(46) DEP ↯ — Assign $*$ to every morpheme M
such that for some phonological unit in M
its output activation is greater than its input activation

CONSISTENCY ↯ — Assign $*$ to every phonological element E in morpheme M such that
E changes its input activity A to output activity A'
and there is a distinct phonological element E' in M with input activity A
that doesn't undergo the same change in activity

(47-i) shows the extension of /-si(mi)/ at the Word Level if the affix is final, i.e. upgrading the activity of /mi/. The violation of DEP ↯ is tolerated to satisfy the higher ranked TEMPLATE SATISFACTION constraints (abbreviated here as ∀TSAT). An alternative repair by metathesis (47-i-b) is excluded by the undominated LINEARITY constraints (∀LIN, at the Word Level of Rarámuri no segmental/affixal reordering happens at all). On the other hand, if /-si(mi)/ is followed by a suffix as in (47-ii), TSAT is satisfied for free, and upgrading its activity (47-ii-b) or reordering ist segments (47-ii-c) is excluded since it would incur unnecessary violations of DEP ↯ and LINEARITY.

(47) i. Input: nári-simiσ$_{\text{MOT}}$ (Word Level)

(34d)	∀LIN	∀TSAT	CON ↯	DEP ↯
a. nári-simiσ		*!		
b. ná-si-ri	*!			
c. nári-simi			*!	*
☞ d. nári-simi				*

ii. Input: wikará-simiσ$_{\text{MOT}}$-ka (Word Level)

(34d)	∀LIN	∀TSAT	CON ↯	DEP ↯
☞ a. wikará-si-ka				
b. wika-si-rá-ka	*!			
c. wikará-simi-ka			*!	*
d. wikará-simi-ka				*!

Crucially, the same constraints also derive variable affix reordering at the Stem level. Here, DEP ↯ is ranked above TSAT, hence /-si(mi)/ is not extended to its bisyllabic form. However, the ranking of LINEARITY and TSAT is not fixed by the master ranking. (48-i) and (48-ii) show the different outputs under both possible rankings licensed by the master ranking. If LINEARITY outranks TSAT (48-i), no change is possible since TSAT is ranked lower than both relevant faithfulness constraints. On the other hand, if TSAT is ranked higher than LINEARITY, (48-ii), TSAT will enforce reordering.

(48) i. Input: sú-ti$_{\text{CAUS}}$-→-simiσ$_{\text{MOT}}$ (Stem Level)

(34d)	CON ↯	DEP ↯	LIN	TSAT
☞ a. sú-ti-simiσ				*
b. sú-ti-simi	*!	*		
c. sú-ti-simi		*!		
d. sú-si-ti			*!	

ii. Input: sú-ti$_{\text{CAUS}}$-→-simiσ$_{\text{MOT}}$ (Stem Level)

(34d)	CON ↯	DEP ↯	TSAT	LIN
a. sú-ti-simiσ			*!	
b. sú-ti-simi	*!	*		
c. sú-ti-simi		*!		
☞ d. sú-si-ti				*

Note that in (48-ii), no further changes will apply to the form at the Word Level since the subcategorization of /-si(mi)/ is deleted via subcategorization discharge at the end of the Stem Level. In contrast, the output of pf (48-i) will lead to extension of /-si(mi)/ at the Word Level in the same way as we have shown for (47-i).

In (43-44), where Associated Motion scopes over Causative and the Causative allomorph involved is /ti/, reordering of /-si(mi)/ and /ti/ is optional and depends on the ranking of LIN(EARITY) and TSAT, which is variable in that both rankings are possible. In (47-ii), TSAT is ranked higher than LIN and therefore triggers reordering of /-si(mi)/ and /ti/ to fulfill the subcategorization requirement of /-si(mi)/ for a syllable to its right, yielding the non-compositional ordering in (44).

3.4 The Interaction with Stress: Left Dislocation of Desiderative /-na(le)/

Left-dislocation is also found for the Desiderative. Thus when the Desiderative has scope over Associated Motion, we find both the compositional order, /-na(le)/ outside of /-si(mi)/ as in (49), and left dislocation as in (50), where /-na(le)/ is inside of /-si(mi)/:

(49) *Compositional order of Associated Motion and Desiderative*

a. DES ▷ MOT (compositional order)

nihé	ko	á	riʔi-bú-**s**-**nare**	buʔucími
|nihé	ko	á	riʔi-bú-**si**-**nale**	buʔucími|
/nihé	ko	á	riʔi-bú-**si(mi)**-**na(le)**	buʔucími/
1SG.NOM	EMPH	APP	stone-remove-**MOT**-**DES**	road

'I want to go along the street removing stones' (2010:176:18-a)

b. DES ▷ MOT *(compositional order)*

tó-**s**-**nare**=ni
|tó-**si**-**nale**|
/to-**si(mi)**-**na(le)**=ni/
take-**MOT**-**DES**=1SG.NOM

I want to go along taking them (2010:176:18-b)

(50) DES ▷ MOT *(non-compositional order)*

kurí	uʔpá	naparí=n	ku	simí-ka	koci-**nál**-**si**-a=n	iná-ri
|kurí	uʔpá	naparí=n	ku	simí-ka	koci-**nále**-**si(mi)**|	
/kurí	uʔpá	naparí=n	ku	simí-ka	koci-**ná(le)**-**si(mi)**-a=ni	iná-li/
just	last	REL=1SG.NOM	REV	go-GER	sleep-**DES**-**MOT**-PROG-1SG.NOM	go-PST

'Last time I went there, I wanted to go along sleeping' (2010:189:35-c)
(translation corrected/reconstructed from Caballero's description and Spanish translation)

Whereas Caballero treats this as another case of free variation, there is again a systematic correlation of left dislocation and the specific morphophonology of the affix which undergoes it. Thus left dislocation of /-na(le)/ seems to be restricted to cases where /-na(le)/ receives stress and the root doesn't have inherent stress. These observations are connected to another unique feature of /-na(le)/. In contrast to all other Stem-Level suffixes involved in noncompositional ordering, it may carry word stress if it attaches to a stressless base. Moreover, if it carries stress it appears in its long form even if it is non-final. Both properties are illustrated by (51-a). (51-b,c) show that – like /-si(mi)/, /-na(le)/ appears in its long form in word-final position independently of the underlying stress of its base. The short form only appears if the base lacks underlying stress and /-na(le)/ is followed by at least one more suffix (51-d):

(51) *Long and short allomorphs of Desiderative /-na(le)/*

a. *Underlyingly stressless root + stressed long /-na(le)/*
ko?**-nári**-mi
|ko?**-nále**|
/ko?**-na(∗le)**-mi/
eat**-DES**
'(s)he would like to eat' (2008:295+296: 18-b)

b. *Underlyingly stressless root + unstressed long /-na(le)/*
ubá**-niri**
|ubá**-na(∗le)**|
/uba**-na(∗le)**/
bathe**-DES**
'(s)he wants to bathe' (2008:149:50-e)

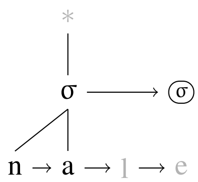
c. *Underlyingly stressed root + unstressed long /-na(le)/*
sutubéci**-niri**
|sutubéci**-na(∗le)**|
/sutubéci**-na(∗le)**/
trip**-DES**
'(s)he wants to trip' (2008:295+296:18-b)

d. *Underlyingly stressed root + unstressed short /-na(le)/*
sú**-ni**-ra
|sú**-na(∗le)**|
/sú**-na(∗le)**-ra/
sew**-DES**-REP
'(s)he repeatedly likes to sew' (2008:295+296:18-b)

At this point, it is necessary to discuss stress in the Rarámuri in somewhat more detail. Rarámuri has a lexical stress system where stress is restricted to an initial 3-syllable window. Caballero (2008, 2011a) argues that suffixes may trigger different stress co-phonoogies, but here we will make the simpler assumption following Bogomolets (2020) that they – just like roots – may either have or lack underlying accent. If a root has underlying stress, this is obligatorily realized. Otherwise, with an underlyingly unstressed root, the stress of an underlyingly stressed suffix is realized if it is inside the 3-syllable window. Underlying suffix stress may also shift locally from the fourth to the third syllable, but not from any syllable more to the right. Note also that this kind of shift is only possible if the target syllable is part of the root. Finally, if neither the root nor any suffixes have underlying stress (or if there is only underlying suffix stress, which cannot reach the initial 3-syllable window), default stress on root appears, which is on the 2nd syllable if the root is longer than one syllable, and otherwise on the monosyllabic root.

To model the special connection which /-na(le)/ establishes between its accentedness and segmental allomorphy, we use again Gradient Symbolic Representations. Thus the representation for /-na∗le/ given in (52) is only a slight extension of the one proposed for /-si(mi)/ above. /na/ is followed by a subcategorization of a following syllable and the weakly activated segments /le/, to account of the length alternation depending on its right context. However, in addition, the syllable dominating /na/ is also associated to a weakly activated accent grid mark.

(52)

a. 

b. *Shorthand:* -na∗le

This representation allows to directly link the stressedness of /-na(le)/ with appearance of its long variant. Since we don't have the space to develop a complete formal analysis of Rarámuri stress, we will only use the cover constraints 1∗ ('Assign ∗ to every Prosodic Word which has more or less than one stress'), 3σ⊡ ('Assign ∗ to every Prosodic Word which has more stress to the right of the 3rd syllable') and DEP ∗ ('Assign ∗ to every epenthetic accent grid mark'). The latter constraint ensures that underlying stress is preferred over (epenthetic) default stress. We assume that DEP ∗ is variably ranked with respect to DEP ↯. (53) shows the simple case where /-na(le)/ is directly attached to a root without underlying accent under the ranking DEP ∗ ≫ DEP ↯ (example (51-b)). To avoid epenthetic stress violating DEP ∗ as in (53-b), the full activation of /-na(le)/'s weak grid mark is tolerated (the epenthetic accent in (53-b) is marked by background shading). But once DEP ↯ is violated, by realizing /-na(le)/'s accent, CON ↯ enforces that its segments are also realized. Full activation of the weak grid mark thus triggers full activation of the weak segments as a side effect:

(53) **Input:** ko-na∗le(σ)$_{\text{DES}}$-mi (51-a)

	1∗	3σ⊡	CON ↯	DEP ∗	DEP ↯	TSAT	LIN
a. ko na le	*!					*	
b. ko na le (∗ on ko, ∗ on na)				*!			*
c. ko na le (∗ on na)			*!		*		
☞ d. ko na le (∗ on na)					*		

Whereas Caballero claims that /-na(le)/ always carries stress with roots lacking underlying accent, there seems to be some variability. Thus the root /uba/ 'bathe' is underlyingly stressless (2008:186-187), but occurs with unstressed [-nale]: ([ubá-niri], 2008:296). We model this variation by the possible reranking of DEP ↯ above DEP ∗. All upgrading of activation for /-na(le)/ as in (54-b,c) is avoided, resulting in default stress and the short variant of /-na(le)/. Note that weak /(le)/ will be fully activated at the Word Level where TEMPLATE SATISFACTION is ranked above DEP ↯ (as shown for /-si(mi)/ in (47-i)).

(54) **Input:** uba-na∗le(σ)$_{\text{DES}}$ (51-b)

	1∗	3σ⊡	CON ↯	DEP ↯	DEP ∗	LIN	TSAT
a. u ba na le(σ)	∗!						∗
b. u ba na le				∗!			
c. u ba na le(σ)			∗!				
d. u ba na le			∗!	∗!			
☞ e. u ba na le(σ)					∗		∗

If the root has underlying accent, accent comes effectively for free, no accent epenthesis is necessary, and DEP ∗ becomes irrelevant. Hence, activation upgrading of /-na(le)/ is blocked independently of its relative ranking with DEP ↯:

(55) **Input:** sú-na∗le(σ)$_{\text{DES}}$ (51-d)

	1∗	3σ⊡	CON ↯	DEP ∗	DEP ↯	LIN	TSAT
☞ a. su na le(σ)							∗
b. su na le(σ)			∗!	∗!			
c. su na le				∗!			∗

Up to this point, we have only modeled the general allomorphy of /-na(le)/ without considering affix order. However, the constraint ranking developed for the general behavior of the suffix also accounts for the possibility of left dislocation, as shown by the tableau in (56). If DEP ∗ outranks DEP ↯, also violation of low-ranked LINEARITY is tolerated to avoid a DEP ∗ violation as in (56-c), and /-na(le)/ is moved in front of /-si(mi)/ to provide an underlying accent inside the 3-syllable window:

(56) **Input:** koci-simiσ$_{\text{MOT}}$-→-na∗leσ$_{\text{DES}}$ *(Stem-Level evaluation)* (50)

	1∗	3σ⊡	DEP ∗	DEP ↯	TSAT	LIN	TSAT
a. ko ci siσ naσ	∗!				∗		∗
b. ko ci si na le (∗ on na)		∗!					
c. ko ci si na le (∗ on ci)			∗!				
d. ko ci na le si mi (∗ on na)				∗∗!		∗	
☞ e. ko ci na le siσ (∗ on na)				∗	∗	∗	

Again, variation results from the option to rank DEP ↯ above DEP ∗. This is illustrated with example (49-b) in (57). Strengthening of /(le)/ in /-na(le)/ is avoided at the cost of epenthetic accent, and consequently no violation of LINEARITY is necessary (again strengthening/extension of /-na(le)/ happens in the Word-Level evaluation):

(57) **Input:** to-simiσ$_{\text{MOT}}$-→-na∗leσ$_{\text{DES}}$ *(Stem-Level evaluation)* (49-b)

	1∗	3σ⊡	DEP ↯	DEP ∗	TSAT	LIN	TSAT
a. to si na leσ (∗ on na)	∗!						∗
☞ b. to si na leσ (∗ on to)				∗			∗
c. to na siσ (∗ on to)				∗	∗!	∗	
d. to si na le (∗ on na)		∗!	∗	∗			
e. to na le siσ (∗ on na)			∗!		∗		

The stress-based approach to the left-dislocation of /-na(le)/ makes a clear empirical prediction: /-na(le)/ cannot left-dislocate with an underlyingly accented root since realization of the root accent will satisfy both DEP ∗ and DEP ↯ without further faithfulness violations. This is illustrated in (58) for example (49-a). Deletion of the underlying root accent as in (58-b) is marked here by black background shading. Shifting /-na(le)/ without strengthening it (58-c) adds an unnecessary LINEARITY violation and is also worse for TSAT since the subcategorization requirement of /-si(mi)/ is stronger than the one of /-na(le)/ (see section 3.5 below for more systematic discussion). Moving and strengthening the accent of /-na(le)/ as in (58-d) leads to an illicit accent outside of the 3-syllable window. Even if we allow for left dislocation of /-na(le)/ and further shifting of its accent as in (58-e), the resulting candidate fares worse than the faithful input candidate in (58-a) which doesn't involve a violation of DEP ↯:

(58) **Input:** riʔibú-simi(σ)$_{\text{MOT}}$-(→)-na∗le(σ)$_{\text{DES}}$ *(Stem-Level evaluation)* (49-a)

	1∗	3σ⊡	DEP ∗	DEP ↯	TSAT	LIN	TSAT
☞ a. ri ʔi bu si na le(σ)							∗
b. ri ʔi bu si na le		∗!		∗			
c. ri ʔi bu na si mi(σ)					∗!	∗	
d. ri ʔi bu na si mi(σ)		∗!		∗	∗	∗	
e. ri ʔi bu na si mi(σ)				∗!	∗	∗	

3.5 Conflict and Strength of Subcategorization

Up to this point we have rather implicitly posited different strengths (activation levels) for subcategorizations. In this section, we will argue in detail how this analysis is crucial for modelling the Rarámuri data as phonological optimization.

Recall first that our analysis of length-alternating suffixes is based on the assumption that all three of them, /-ca(ne)/, /-si(mi)/ and /-na(le)/, subcategorize for a following syllable. which accounts for their long and short variants. At the same time, this subcategorization triggers reordering of affixes. Now assume that subcategorizations would not be distinguished by their lexical strength. Then the overall analysis of length alternating suffixes would be undermined by the very fact that /-si(mi)/ may dislocate across /-na(le)/ as in (59):

(59) MOT ▷ DES *(non-compositional order)*

ne we koʔá-**s**-**niri**
|ne we koʔá-**si(mi)**-**na(∗le)**|
/ne we koʔa-**si(mi)**-**na(∗le)**/
1SG.NOM INT eat-**MOT**-**DES**-PROG
'I'm going along wanting to eat' (2010:188:35-a)

Under the assumption that all subcategorizations have equal strength, this derivation would look schematically as in (60):

(60) -na(σ)-si(σ) → -si(σ)-na(σ)

However, in the constraint-based system assumed here, (60) results in a paradox: Whereas left-dislocation of /-si(mi)/ leads to an improvement for /-si(mi)/ (which is followed by a syllable in the output, but not in the input), it means a change to the worse for /-na(le)/ (which is followed by a syllable in the input, but not in the output). Given that reordering independently violates LINEARITY, we would expect that a derivation as in (60) is excluded under any constraint weighting (it would be *harmonically bounded* in the sense of Prince & Smolensky 1993). The same dilemma emerges with left-dislocation by /-ca(ne)/ across /-na(le)/, and by the left-dislocation of the Causative across Associated Motion as in (61):

(61) CAUS ▷ MOT *(non-compositional order)*

a.

cémale	ko	ne	kajápi	cukú-b-**ti**-**si**-a	iná-ri	martín
|cémale	ko	ne	kajápi	cukú-b-**ti**-**si**-a	iná-ro	martín|
/cémale	ko	ne	kajápi	cukú-b-**ti**-**si**-a	iná-ri	martín/
Chemale	EMPH	INT	frequently	stop-INCH-**CAUS**-**MOT**-FUT.SG	go-MOV	Martin

'Chemale made Martin go along stopping (the truck)' (2010:176:18-a)

b.

mi=n	piwá-**r**-**si**-mo	rá
|mi=ni	piwá-**r**-**si(mi)**	olá|
/mi=ni	pewa-**r**-**si(mi)**-ma	olá/
2SG.ACC=1SG.NOM	smoke-**CAUS**-**MOT**-FUT.SG	CER

'I'll make you go along smoking' (2010:188:34-b)

As shown in (62), movement of /-r-ti/ across /-si/ is again a zero sum game, where one subcategorization violation (/-r-ti/ occuring after the stressed syllable) is traded against another one ([-si] being followed by another syllable), which should be excluded by LINEARITY:

(62) cukúb-si(σ)-(*σ)r-ti → cukúb-(*σ)r-ti-si(σ)

Still, the relevant cases are not arbitrary, but show a clear pattern of implicational strength. Associated Motion and Evidential can left-dislocate across the Desiderative, but not across Causative /-r-(ti)/. In contrast, Causative /-r-ti/ can left-dislocate across Desiderative and Associated Motion (recall that under our analysis the morphology always positions the the Evidential in rightmost position thus Stem-Level left dislocation across the Evidential is not an option to begin with):

(62) Causative /-r-(ti-)/ > {Associated Motion, Evidential} > Desiderative

Gradient Symbolic Representations offer a natural implementation for this hierarchy by assigning different strengths to subcategorization requirements as in (63), where the subcategorization of Causative /-r/ is strongest (63-d), the one of /-na(le)/ is weakest (63-a) while /-si(mi)/ (63-b) and /-ca(ne)/ (63-c) have intermediate-strength requirements (and /-ca(ne)/ also has a weak requirement for a syllable to its right triggering its length alternation).

(63) *Different degrees of subcategorization strength*

a. Weak subcategorization: -na∗le(σ) (Desiderative)
b. Medium-strength subcategorization: -simi(σ) (Associated Motion)
c. Medium-strength and *weak* subcategorization: (∗σσ)cane(σ) (Evidential)
d. Strong subcategorization -(∗σ)r (Causative)

These representations become effective by replacing the categorial constraint *Template Satisfaction* from 20 by three more elaborate versions which are differentially sensitive to strength of subcategorization:[9]

(64)

a. TEMPLATE SATISFACTION — Assign ∗ to every selectional subgraph S of a phonological representation R which doesn't match R

b. TEMPLATE SATISFACTION — Assign ∗ to every selectional subgraph S of a phonological representation R which doesn't match R such, where some node in S is at least of intermediate strength

c. TEMPLATE SATISFACTION — Assign ∗ to every selectional subgraph S of a phonological representation R which doesn't match R such, where some node in S is strong

The derivation of (59) in (65) illustrates how this resolves the paradox of conflicting subcategorizations. DEP ↯ is ranked here above DEP ∗ so that /-na(le)/ cannot be fully realized as in (65-a), hence its weak accent remains irrelevant, and affix order is solely determined by subcategorization. At this point, TEMPLATE SATISFACTION favors dislocation of /-si(mi)/ because the subcategorization of /-si(mi)/ has intermediate-strength (65-c) whereas the weak subcategorization of /-na(le)/ violates only lower-ranked TEMPLATE SATISFACTION (extension of /-na(le)/ again takes place only at the Word Level):

(65) *Left-dislocation of /-si(mi)/ across /-na(le)/ (59)*

Stem Level: **Input:** koʔa-na∗le(σ)$_{\text{DES}}$-(→)-simi(σ)$_{\text{MOT}}$

	DEP ↯	DEP ∗	TSAT	LIN	TSAT
a. koʔa-nále-$_{\text{DES}}$-simi$_{\text{MOT}}$	*!*				
b. koʔ'a-nale$_{\text{DES}}$-simi$_{\text{MOT}}$	*!	*		*	
c. koʔá-nale$_{\text{DES}}$ -simi(σ)$_{\text{MOT}}$		*	*!		*
☞ d. koʔá-simi$_{\text{MOT}}$-nale(σ)$_{\text{DES}}$		*		*	*

Word Level: koʔá-simi$_{\text{MOT}}$-nale(σ)$_{\text{DES}}$ → koʔá-simi$_{\text{MOT}}$-nale$_{\text{DES}}$

Note that the relative constraint ranking of TSAT and TSAT is irrelevant for the evaluation in (65). (65-d) would also win over (65-c) if the ranking of both constraints was reversed. This is because the constraints in (64) stand in a *stringency relation* in the sense of de Lacy (2002). Every undischarged subcategorization violating TSAT also violates TSAT, and every undischarged subcategorization violating TSAT also violates TSAT and TSAT. This captures the intuition that the satisfaction of stronger subcategorizations is inherently preferred, independently of language-specific grammars. Constraint ranking of the TSAT constraints will however become relevant in their relative ranking

[9] See section 5.2 on an alternative implementation of strength-sensitive TSAT in Harmonic Grammar, which requires only a single version of the constraint.

with respect to other constraints. Thus we will see in section 3.6 below that TSAT must be ranked above DEP ∗ whereas TSAT and TSAT must be ranked below DEP ∗.

The derivation for example (61-a) is similar. Causative /-r-ti/ moves across /-si(mi)/ since the resulting subcategorization violation in (66-d) is of intermediate strength whereas the original order in (66-a) conserves the strong subcategorization of /-r/. Only moving Causative /-r/ but not /-ti/ as in (66-c) would satisfy both subcategorizations, but is in conflict with undominated MORPHOLOGICAL CONTIGUITY (see section 3.1):

(66) *Left-dislocation of /-r-ti/ across /-si(mi)/ (61-a)*

Stem Level: **Input:** cukúb-simiσ$_{\text{MOT}}$-→-∗σr-ti$_{\text{CAUS}}$

	MORPHCTG	TSAT	DEP ↯	DEP ∗	TSAT	LIN
a. cukúb-simi$_{\text{MOT}}$-∗σr-ti$_{\text{CAUS}}$		*			*	
b. cukúb-r$_{\text{CAUS}}$-simi$_{\text{MOT}}$-ti$_{\text{CAUS}}$	*!					*
c. cukúb-r-ti$_{\text{CAUS}}$-simi$_{\text{MOT}}$			*!			**
☞ d. cukúb-r-ti$_{\text{CAUS}}$-simiσ$_{\text{MOT}}$					*	**

Word Level: cukúb-r-ti$_{\text{CAUS}}$-simiσ$_{\text{MOT}}$-a → cukúb-ti$_{\text{CAUS}}$-si$_{\text{MOT}}$-a

Note that there is also more circumstantial evidence for the strength assignments assumed here in the overall Stem-level paradigm of Rarámuri. For example, the left subcategorization of Causative /-r/ is intuitively stronger than the one of the Evidential since *all* instances of /-r/ are in the coda of a stressed syllable, but the Evidential may be separated from the stressed syllable by more than one syllable as in (67) below, or by less as in the examples in (25) violating its subcategorization. All three length-alternating suffixes /-na(le)/, /-si(mi)/, and /-ca(ne)/ subcategorize for a syllable to their right accounting for their extension if they are not followed by another suffix. However, only the right-subcategorized syllable of /-si(mi)/ assigned here intermediate strength seems to actively trigger non-compositional orderings. All cases of left-dislocation for /-na(le)/ are triggered by its underlying accent, not by its subcategorization as in example (50). Similarly all left dislocation of /-ca(ne)/ can be motivated by its subcategorization for a σ́σ sequence to its left, there are no cases of left-dislocated /-ca(ne)/ where the latter requirement is not met (see section 3.1).

In the following section, we will show that subcategorization strength also plays an important role in cases where left-dislocation of affixes is expected but blocked.

3.6 Blocking Dislocation: Strength of Linearization vs. Strength of Subcategorization

Consider again the overall distribution of affix order in Rarámuri. Our analysis at this point accounts for virtually all cases where Causative, Desiderative or Associated Motion left-dislocate (Applicative never left-dislocates because it never has scope over any of the other affixes). In the table, the cases of dislocation correspond to the second order listed in a given cell.

higher → lower ↓	APP	CAUS	DES	MOT	EV
APP		APPL-CAUS CAUS-APP	APPL-DES (DES-APP)	APPL-MOT	APPL-EV
CAUS	✗		CAUS-DES	CAUS-MOT MOT-CAUS	CAUS-EV
DES	✗	DES-CAUS CAUS-DES		DES-MOT MOT-DES	DES-EV EV-DES
MOT	✗	MOT-CAUS CAUS-MOT	MOT-DES DES-MOT		MOT-EV
EV	✗	✗	✗	✗	

Table 2: Attested and unattested scopes in syntactic and aspectual stem levels (2010:190)

However, if Caballero's generalizations are correct, there are also many affix combinations where dislocation would be clearly motivated, but seems to be systematically blocked. For example, we would expect that Evidential /-ca(ne)/ dislocates to the left of Applicative /-ki/ or Causative /-ti/ to satisfy its prosodic subcategorization, but /-ca(ne)/ seems to systematically dislocate only across /-na(le)/, not any other of the Stem-Level affixes. A concrete example is shown in (67), where /-ca(ne)/ is separated from the stressed syllable by two syllables at the Stem Level, leading to a violation of its subcategorization requirement, thus we would expect *|rarahípa-ca-ti|.

(67) EV ▷ CAUS *(compositional ordering)*
rarahíp-**ti**-**cane**
|rarahípa-**ti**-**ca**|
/rarahípa-**ti**-**ca(ne)**/
run.race-CAUS-EV=1SG.NOM
'It sounds like running a race' (2008:69:T-7)

Apparently, some combinations of affixes are amenable to reordering whereas other combinations are not. Again, Gradient Symbolic Representations provide a natural account if we assume that different pairs of affixes show different amounts in their strength of linearization. Thus we posit that combinations of Associated Motion and Evidential as in (67) show strong underlying linearization, effectively blocking reordering, whereas other affix pairs exhibiting free dislocation of affixes (e.g. Causative and Applicative) have weak linearization. The table in (68) lists the strength of linearization we assume for the combinations of all relevant affixes:

(68) *Linearization strength of different affix pairs*

	APP	CAUS	DES	MOT	EV
APP	*				
CAUS		*			
DES			*		
MOT				*	
EV					*

Note two crucial aspects of our implementation of linearization strength. First, as obvious from inspection of (67), strength is symmetric. Thus whether semantics and morphology lead to the underlying linearization MOT-DES or DES-MOT, their linearization strength is the same (weak). Similarly, both CAUS-DES and DES-CAUS exhibit strong linearization. *Second,* strength of linearization is an arbitrary feature of affix *combinations*, not of single affixes. Thus the combination of APP and MOT shows strong linearization even though both MOT and APP show weak linearizations in other combinations. We ultimately expect that there are more systematic reasons behind linearization strength (e.g., the frequency or the semantic confoundability of affix combinations, see Hyman 2003 for discussion), but at this point we treat linearization strength simply as lexical information which has to be learned by speakers for every given pair of affixes in a language which cooccur under adjacency. Note finally that linearization strength, although it shows some parallelism to the affix bigrams proposed by Ryan (2010), is very different in nature. Intuitively, Ryan-style bigrams encode a preference for a *specific* ordering of two affixes (e.g. 'MOT should precede EV under adjacency'). In contrast, positing strong linearization on the combination of MOT and DES is perfectly compatible with both orders of these affixes. It simply encodes that both combinations are more resistant to reordering by morphophonological constraints than other affix combinations.

Let us demonstrate more in detail the motivation for different strengths of linearization and different corresponding LINEARITY constraints. TEMPLATE SATISFACTION must be ranked variably with some version of LINEARITY to ensure, for example, that even with underlyingly stressed roots in a MOT ▷ DES configuration /-si(mi)/ either can left-dislocate as in (68) or not (69):

(68) MOT ▷ DES *(non-compositional ordering)*

ne=n	nará-**s**-**nir**-a	iná-ro
|ne	nará-**si(mi)**-**na(∗le)**	iná-ro|
/ne	nará-**si(mi)**-**na(∗le)**-a	iná-ro/
INT=1SG.NOM	cry-**MOT**-**DES**-PROG	go-MOV

'I'm going along wanting to cry' (2010:189)

(69) MOT ▷ DES *(compositional ordering)*

ne	isí:**-n-si**-a	iná-ro
|ne	isí:**-na(∗le)-si(mi)**	iná-ro|
/ne	isí:**-na(∗le)-si(mi)**-a	iná-ro/
1SG.NOM	urinate**-DES-MOT**-PROG	go-MOV

‘I’m going along wanting to urinate’ (2010:177:19-c)

(70) and (71) show how this variation is derived from variable reordering of unordered LINEARITY and TEMPLATE SATISFACTION:

(70) **Input:** nará-na∗le σ$_{DES}$-→-simi σ$_{MOT}$ (68)

	1∗	3σ⊡	DEP ↯	DEP ∗	TSAT	LIN	TSAT
a. na $\overset{*}{\text{ra}}$ na si σ					∗!		∗
☞ b. na $\overset{*}{\text{ra}}$ si na σ						∗	∗
c. na $\overset{*}{\text{ra}}$ na si mi			∗!				

(71) **Input:** isí-na∗le σ$_{DES}$-→-simi σ$_{MOT}$ (69)

	1∗	3σ⊡	DEP ↯	DEP ∗	LIN	TSAT	TSAT
☞ a. i $\overset{*}{\text{si}}$ na si σ						∗	∗
b. i $\overset{*}{\text{si}}$ si na σ					∗!		∗
c. i $\overset{*}{\text{si}}$ na si mi			∗!				

On the other hand, the blocking of dislocation discussed above for (67) seems to be absolute, hence strong linearization always blocks reordering triggered by weaker subcategorization. This follows from positing two higher-ranked versions of TSAT and LIN which are only sensitive to strong subcategorization and linearization. Thus as shown in (72), LINEARITY preserves the underlying morpheme order independently from the specific ranking of LIN and TSAT:

(72) *Blocking of dislocation by strong linearization* **Input:** rararahípa-ti$_{CAUS}$-→-cane σ$_{EV}$

	TSAT	LIN	DEP ∗	TSAT	LIN	LIN	TSAT
☞ a. rarahípa-ti-∗σσcane σ				∗			∗∗
b. rarahípa-cane-ti		∗!			∗	∗	

On the other hand TSAT may enforce reordering in cases with weak subcategorization as in (70) and (73):

(73) *No blocking of dislocation with weak linearization* **Input:** atísi-nale(σ)$_{\text{DES}}$-(→)-(∗σσ)cane(σ)$_{\text{EV}}$

	TSAT	LIN	DEP ∗	TSAT	LIN	LIN	TSAT
a. atísi-na-(∗σσ)cane(σ)				∗!			∗
☞ b. atísi-ca-nale(σ)						∗	∗

This analysis also accounts for the fact that Evidential doesn't dislocate with respect to Applicative and Associated Motion, and that Associated Motion cannot dislocate across the Applicative. In all these cases, as in (73), strong linearization trumps the moderate-strength subcategorization of /-ca(ne)/ and /-si(mi)/.

The situation is more complex for combinations of the Causative and the Desiderative where the symmetry seems to break down. There is reordering if the Desiderative has scope over the Causative (74-a), but there is no reordering attested for the opposite scope (74-b):

(74) *Non-compositional order of Causative and Desiderative (Caballero 2010)*

a. CAUS ▷ DES *(non-compositional order)*
ko?á-**r-ti-ni**-sa
|ko?á-**r-ti-na**|
/ko?a-**r-ti-na(le)**-sa/
eat-**CAUS-CAUS-DES**-IMP
'Let's make her want to eat!' (2010:187)

b. DES ▷ CAUS *(compositional order)*
ko?á-**r-ti-nare**
|ko?á-**r-ti-nale**|
/ko?a-**r-ti-na(∗le)**/
eat-**CAUS-CAUS-DES**
'She wants to make him eat!' (2008:95)

In cases where the Causative is realized, dislocation directly follows from the fact that /-r/ has strong subcategorization, and TSAT is ranked above LIN:

(75) *Enforcing dislocation by strong subcategorization* **Input:** ko?a-na∗le(σ)$_{\text{DES}}$-(→)-(∗σ)r$_{\text{CAUS}}$-ti$_{\text{CAUS}}$ (74-a)

	CON ↯	TSAT	LIN	DEP ∗	DEP ↯	TSAT	LIN	LIN	TSAT
a. ko?a-nále-(∗σ)r-ti		∗!			∗	∗			∗
b. ko?a-nál-r-ti	∗!			∗					
c. ko?á-na∗le-(∗σ)r-ti		∗!				∗			∗
☞ d. ko?á-r-ti-na∗le(σ)			∗	∗			∗	∗	∗

Conversely subcategorization also blocks dislocation for the opposite-scope input in (74-b): This follows because /-r/'s subcategorization is strong and TSAT is undominated:

(76) *Strong subcategorization blocks dislocation* **Input:** ko?a-(∗σ)r$_{\text{CAUS}}$-ti$_{\text{CAUS}}$-(→)-na∗le(σ)$_{\text{DES}}$ (74-b)

	CON ↯	TSAT	LIN	DEP ∗	DEP ↯	TSAT	LIN	LIN	TSAT
☞ a. ko?á-r-ti-na∗le(σ)					∗				∗
b. ko?a-nále-(∗σ)r-ti		∗!	∗		∗	∗	∗	∗	∗
c. ko?a-nál-r-ti	∗!				∗				
d. ko?á-na∗le-(∗σ)r-ti		∗!	∗	∗		∗	∗	∗	∗

Note that our analysis predicts that Desiderative could (optionally) left-dislocate across Causative, but only under very specific circumstances. The Causative would have to be realized by the /ti/-allomorph (otherwise its subcategorization would block dislocation as in (76), and the root would have to lack underlying accent (otherwise LINEARITY would block dislocation). Unfortunately, Caballero's published work does not contain examples of this type, hence this prediction awaits further empirical investigation.

(77) *Blocked reordering for* DES ▷ CAUS *(Caballero 2010)*

a. DES ▷ CAUS *(compositional order)*

nihé	mi	awí-**r**-**nare**
|nehé	mi	awí-**r**-**nale**|
/nehé	mi	awi-**r**-**nale**/
1SG.NOM	2SG.ACC	dance-**CAUS**-**DES**

'I want to make you dance' (2010:180:23)

b. DES ▷ CAUS *(compositional order)*

koʔá-**r**-**ti**-**nare**
|koʔá-**r**-**ti**-**nale**|
/koʔa-**r**-**ti**-**na(∗le)**/
eat-**CAUS**-**CAUS**-**DES**
'She wants to make him eat!' (2008:95)

Note also two further predictions of our analysis for blocking of reordering which are un expected under Caballero's approach. Shifting of CAUS /-ti/ across /-na(le)/ in forms like (78) is excluded: /-ti/ by itself doesn't have any subcategorization, hence shifting it would only have disadvantages. /-na(le)/'s subcategorization for a right-adjacent syllable would no longer be satisfied. /-na(le)/ couldn't contribute its accent across /-ti/, and there would be a LINEARITY violation:

(78) *Blocked reordering for* CAUS ▷ DES

mi=ni	awi-**nár**-**ti**-ma	orá
|mi=ni	awi-**nále**-**ti**	orá|
/mi=ni	awi-**na(∗le)**-**ti**-ma	orá/
2SG.ACC=1SG.NOM	dance-**DES**-**CAUS**-FUT.SG	

'I will make you want to dance' (2010:179:22)

Our analysis also predicts that DES /-na(le)/ cannot shift across MOT /-si(mi)/ if the root complex has underlying stress as in (49a) above. This is already shown in (58).

4 Empirical Predictions and Questions

The central difference between the morpohotactic analysis by Caballero and our reanalysis is that the latter makes highly specific predictions on the correlation of non-compositional affix order with independent phonological properties of the involved affixes and the specific forms. We have already mentioned some of these predictions in passing. Here, we will summarize them more systematically and discuss the empirical evidence for our analysis. To this effect, we have collected virtually all published material by Caballero on the language which contains forms with multiple Stem-Level affixes undergoing dislocation (Caballero 2008, 2010, 2011a,b, 2022) in an Excel database, have annotated them with information on ordering scope and allomorphy, and have counted the data supporting or contradicting our hypotheses.

Before we present our results, let us first talk about the qualitative nature of the empirical sources we use. The published materials by Caballero on the language, which partially overlap in the data they report, provide a rich corpus of data. However, in detail, these data are of very different type. In the articles and chapters where Caballero discusses affix order, she gives explicit information about the scope and readings of single affixes, verified scrutinously with informants (as documented by complete recordings available as .wav files, see Caballero 2015). In other contexts (e.g., in the discussion of stress), forms are given without explicit semantic information and often even without translation so that it is in many cases impossible to retrieve the semantic composition of a given form. Another limitation is information on stress. For testing some of our predictions on /-na(le)/, it is crucial to distinguish verbal roots with underlying accent from those which are underlyingly stressless. For some roots, Caballero provides explicit classifications, for others it can be retrieved from their occurrence in different contexts, but there is a set of verb roots for which their underlying accent remains unclear. See appendix B on a classification of verb roots according to their underlying accent and on our criteria for classification.

4.1 Evidential /-ca(ne)/

Recall that Evidential /-ca(ne)/ always has scope over the other Stem-Level affixes with which it combines. hence under our approach /-ca(ne)/ can left-dislocate with respect to another suffix, but there can never be left-dislocation of another suffix across /-ca(ne)/.

Caballero provides 35 examples where /-ca(ne)/ cooccurs with **Desiderative /-na(le)/**. Unsurprisingly, our evaluation confirms the two central predictions by Caballero (and by our analysis): ① in the 12 cases where /-ca(ne)/ left-dislocates, it achieves the Stem-Level ∗σσ__-template preceding it. ② in the 39 cases where /-ca(ne)/ *doesn't* left-dislocate the order already satisfies the σ́σ-template.

What the data leave largely open is how /-ca(ne)/ behaves with respect to other Stem-Level affixes.

There are only 2 examples where /-ca(ne)/ cooccurs with **Applicative /-ki/**, e.g. [tičí-k-čane] |ticí-ki-cane| comb-APP-EV 'it sounds like X combs Y for Z' (2010:181:25-b). In both examples, the underlying (and Stem-Level) form already satisfies /-ca(ne)/'s σ́σ__ template without further repair/reordering. To evaluate the behaviour, of /-ca(ne)/ in this context, one would have to combine a bisyllabic or trisyllabic root with underlying stress (e.g., /íbi/ 'bring' or /húmisi/ 'take off (pl) ', cf. appendix B) with Applicative /-ki/ and /-ca(ne)/. Caballero's schematic summary of Rarámuri affix ordering (2010:190) predicts that an input such as /íbi-ki-ca(ne)/ would surface in non-compositional order and we have assumed strengths to mimic this prediction: (/-ca(ne)/ has intermediate-strength subcategorization for ∗σσ__, but strong linearization). However, the published sources by Caballero actually provide no positive evidence for this assumption.

The same is true for the 7 examples where /-ca(ne)/ cooccurs with **Associated Motion /-si(mi)/**. Again, in all examples, the Stem-Level representations (e.g., [siná-si-cane] |siná-si-cane| scream-MOT-EV/, 2008:272), already satisfies /-ca(ne)/'s σ́σ__ subcategorization without reordering (given the short variant [-si] of MOT), and only testing with roots like /íbi/ or /húmisi/ would provide actual evidence.

In forms with the **Causative**, one actually finds violations of the Evidential σ́σ__ template. There is 1 example where /-ca(ne)/ combines with Causative /-r/, where the latter forms the coda of the stressed syllable ([ubá-r-cane] |ubá-r-cane| bath-CAUS-EV 'it sounds like X bathes Y' (2010:181,25-a)). This form is similar to the ones in (25), where /-ca(ne)/ also immediately follows the stressed syllable (but without /-r/). While this example violates the σσ́-template, reordering with /-r/ wouldn't improve on this situation and is therefore correctly predicted to be impossible under our analysis.

There are 2 examples where /-ca(ne)/ combines with the other Causative allomorph /-ti/. In 1 of these, /-ca(ne)/'s σσ́-template is already satisfied by the scopal ordering (e.g., [nará-t-can-a-tʃi] |nará-ti-canɛ-a-tʃi| cry-CAUS_ti-EV-PROG.TEMP 'When it sounds like they are making her cry', 2008:299:15-a). The remaining example is example (67) from section 3.6 whose Stem-Level representation |rarahípa-**ti**-**ca**| violates the template, and reordering is blocked – as argued in section 3.6, this is due to the strong linearization of Evidential and Causative.

4.2 Causative [-r]/[-ri]/[-ti]/[-r-ti]

Our analysis predicts that Causative /-r/ should always occur in the coda of the stressed syllable. To test this, we have counted not only the forms with multiple Stem-Level suffixes in our database, but *all* forms with surface Causative [-r] in Caballero's publication. The generalization holds true for all 204 occurrences of Causative [-r].

We also predict that the allomorph /-ri/ should never dislocate across any other Stem-Level affixes. Our database contains overall only one instance of surface [-ri], which has scopal order.

The situation is somewhat more complex with Causative /-ti/ since we have argued that some instances of surface [-ti] are actually underlyingly /-r-ti/, which is deleted at the Word Level to avoid a complex coda. Thus the prediction here is more subtle: Dislocated surface [-ti] should never occur after a vowel and always immediately follow the stressed syllable. These predictions are again borne out: Of the 65 occurrences of [-ti] in our database, only 3 have non-scopal (left-dislocated order). All of these immediately follow a stressed syllable and a coda consonant.

4.3 Desiderative /-na(le)/

A significant prediction not made by Caballero's morphotactic account is that Desiderative /-na(le)/ should never dislocate with underlyingly stressed roots. Note first that the _ σ subcategorization of /-na(le)/ cannot trigger reordering since LIN outranks TSAT. hence all dislocation of /-na(le)/ must be due to DEP ∗. However, as shown in section 3.4, with underlyingly stressed roots, realization of the underlying root accent is always more harmonic than movement since it satisfies the same markedness constraints and less faithfulness constraints. In fact, all the 2 examples in our database with left-dislocated /-na(le)/ have roots for which there is clear evidence that they lack underlying accent.

A second prediction of our analysis for /-na(le)/ is that it may never left-dislocate across Causative /-r/ or /-r-ti/. Recall from 4.2 that /-r/ always occurs as the coda of the stressed syllable. Hence dislocation across /-r/ or /-r-ti/ would always bleed satisfaction of the strong ∗σ_ subcategorization of /-r/. Since left-dislocation of /-na(le)/ is always to satisfy DEP ∗, and TSAT outranks DEP ∗, left-dislocation of /-na(le)/ is impossible. Accordingly, in all examples of our database where /-na(le)/ combines with /-r/ (N= 12) or /-r-ti/ (N= 9), Desiderative has scope over Causative, /-na(le)/ is on the right of /-r(-ti)/.

A third prediction is that Left-dislocated /-na(le)/ should always be stressed (or, possibly, shift its stress to a left-adjacent verbal root): recall from above that the only reason why /-na(le)/ may left-dislocate under our analysis is to provide a stress for the word which implies the surface realization of its accent. The two examples in our database where /-na(le)/ left-dislocates also confirm this prediction.

4.4 Associated Motion /-si(mi)/

We predict that Associated Motion should never left-dislocate across Causative /-r/ or /-r-ti/ since /-si(mi)/ is never stressed, /-r/ has strong subcategorization for a stressed syllable and /-si(mi)/ only intermediate-strength subcategorization for a syllable to its right. In fact, of the 15 combinations of /-si(mi)/ with /-r/ in our database only 4 have non-scopal order, and in all these 4 forms, Causative scopes over Associated Motion but /r/ appears closer to the stem, i.e., it is not Associated Motion /-si(mi) but Causative /-r/ that left-dislocates. The remaining 11 combinations have scopal order and Associated Motion scopes over the Causative.

We also predict that /-si(mi)/ cannot left-dislocate if it is followed by another Stem-Level suffix (in a configuration where it is the middle suffix of 3 Stem-Level suffixes). This holds because the only possible trigger for /-si(mi)/ to left-dislocate is its $\_\,\sigma$ subcategorization at the Stem Level. However if /-si(mi)/ is followed by a syllable at the Stem-Level $\_\,\sigma$ is already satisfied without reordering, and left dislocation would incur unnecessary violation of LINEARITY. Thus, whereas (79-a) is attested, we wouldn't expect to find the reordering pattern in (79-b) (where 'X' stands for any other Stem-Level affix).

(79) a. V-nale-simi $\rightarrow$ V-simi-nale
b. V-nale-simi-X $*\!\rightarrow$ V-simi-nale-X

Unfortunately, our database doesn't contain examples akin to (79-b) which would be decisive for confirming or refuting this prediction. It contains only 5 examples where /-si(mi)/ is 'sandwiched' between two other Stem-Level suffixes. In all of these examples, /-si(mi)/ is preceded by Causative /-r/ for which /-r/'s strong subcategorization independently predicts that /-si(mi)/ cannot cross it. Once more, our evaluation shows the need for retrieving more data.

Finally, we also predict that left-dislocated /-simi/ should always appear in its short variant because the long variant violates DEP ↯ and /-simi/'s $\_\,\sigma$ subcategorization is already satisfied if it is left-dislocated. In fact, all 5 cases of left-dislocated /-simi/ in our database confirm this prediction.

Taken together, our analysis is confirmed by the data in our database drawn from the published work by Caballero. Moreover, the quantitative evaluation makes it clear that for many ordering patterns there are only very few actual examples, and some of the predictions of our analysis can neither be confirmed or be refuted by the published evidence due to the lack of appropriate data. Note that this latter point even holds for a number of claims – especially on the Evidential – made by Caballero herself. In sum, our results reveal the need to collect more and more systematic data from Rarámuri to achieve a better empirical understanding.

5 Alternatives

Throughout this paper, we have provided arguments that a phonological account of Rarámuri affix order is generally superior to one based on morphotactic constraints in the morphology as originally proposed by Caballero (2008, 2010). Here, we discuss two obvious alternatives in the specific implementation of a phonological account by employing different approaches to subcategorization (section 5.1) and by using Harmonic Grammar instead of Optimality Theory (section 5.2).

5.1 Other Implementations of Subcategorization

One standard view of subcategorization is the one advocated by Paster (2006) and Kiparsky (2021): Subcategorization is evaluated as part of morphological affixation: If a base satisfies a subcategorization requirement of an affix, affixation may apply, otherwise it fails (or gives way to a suppletive allomorph). The central prediction of this approach is that subcategorization does not play a role in phonology proper. However, Bermúdez-Otero (2018) argues for a clearly phonological effect of prosodic subcategorization in his analysis of English Level-1 affixes: subcategorization triggers specific morpheme-specific stress shift patterns and applies strictly in the phonology. Similarly, Bennett et al. (2018) and Rolle & Hyman (2019) argue for subcategorization as the source of prosodic smothering, again applying in the phonology, not the morphology. Also for the Rarámuri data, it is crucial that subcategorization is present in the phonology to describe the pattern of alternative repairs for length-alternating suffixes – by affix movement or by realization of weak segments. Another problem for a Paster-style version of subcategorization is that prosodic subcategorization in Rarámuri is apparently violable, as we have shown in section 3.1 for the Evidential /-ca(ne)/.[10]

Caballero (2008) implements subcategorization of the Evidential by a Generalized Alignment constraint (McCarthy & Prince 1993). The central problem with alignment is that alignment cannot be inherited across strata. The only way to satisfy subcategorization either at the Stem or the Word Level would be to abandon Bracket Erasure. Morpheme boundaries would still be fully visible at subsequent strata. This would predict that affixes of lower strata can still be dislocated at higher strata. In contrast, the virtual structure approach to subcategorization is

5.2 Linearization and Subcategorization in Harmonic Grammar

In this paper, we have combined GSR with Optimality Theory to keep the analysis as close (and comparable) as possible to the original one by Caballero and because it provides a simple interpretation of optionality by unranked constraints. An obvious alternative would be to use Harmonic Grammar as in the foundational work on GSR by Smolensky & Goldrick (2016). We illustrate this approach here with two representative examples. (80) repeats (66), where /-r/ left dislocates across /-si(mi)/ from section 3.5.

(80) *Strong subcategorization trumps intermediate linearization strength (Stem Level)*

Input: cukúb-simiσ$_{\text{MOT}}$-→-*σr-ti$_{\text{CAUS}}$

	MORPHCTG	TSAT	DEP ↯	DEP *	TSAT	LIN
a. cukúb-simi$_{\text{MOT}}$-*σr-ti$_{\text{CAUS}}$		*			*	
b. cukúb-r$_{\text{CAUS}}$-simi$_{\text{MOT}}$-ti$_{\text{CAUS}}$	*!					*
c. cukúb-r-ti$_{\text{CAUS}}$-simi$_{\text{MOT}}$			*!			**
☞ d. cukúb-r-ti$_{\text{CAUS}}$-simiσ$_{\text{MOT}}$					*	**

(80) is an implementation of the same derivation in the Harmonic Grammar alternative where all constraints, subcategorizations and linearizations have numerical weightings (for simplicity also with values above 1). On the other hand, there is only one general instance of the TSAT and one instance of the LINEARITY constraints.

[10] For reasons of space, we do not discuss here the idea here that subcategorization is substantial, not virtual phonological structure (Inkelas 1990) since the differences to our approach are subtle. See Bennett et al. (2018); Lionnet & Rolle (2020) for critical discussion.

(80)

Input = cukúb-simi(σ)$_5$-→$_2$-*σ$_{50}$r-ti$_{\text{CAUS}}$

	MorphCtg ∞	Dep ↯ 10	Dep ∗ 10	TSat 4	Lin 3	$\mathcal{H}$
a. cukúb-simi$_{\text{MOT}}$-*σr-ti$_{\text{CAUS}}$				50		-200
b. cukúb-r$_{\text{CAUS}}$-simi$_{\text{MOT}}$-ti$_{\text{CAUS}}$	1					-∞
c. cukúb-r-ti$_{\text{CAUS}}$-simi$_{\text{MOT}}$		1			2	-16
☞ d. cukúb-r-ti$_{\text{CAUS}}$-simi(σ)$_{\text{MOT}}$				2	2	-14

Left dislocation simply results from the fact that both constraints are sensitive to the activation of subcategorization and precedence according to the revised definitions in (81), and that the activation of precedence in (80) outweighs the one of linearization.

(81)

Linearity — Assign violations of amount n to every pair of output segments (S1,S2) whose linearization differs from that of the corresponding input segments (S1',S2') and S1', S2' are linearized with an activation of n

Template Satisfaction — Assign violations of amount n to every selectional subgraph of a phonological representation R which has strength n and doesn't match R

The example in (82) is in many respects the opposite case. Linearization is stronger than subcategorization, and consequently left dislocation is blocked.

(82) *Blocking of dislocation by strong linearization* **Input:** rarahipa-ti$_{\text{CAUS}}$-→-*σσcane(σ)

	TSat	Lin	Dep ∗	TSat	Lin	TSat	Lin
☞ a. rarahípa-ti-*σσcane(σ)				*		*	
b. rarahípa-cane-ti		*!					

In the Harmonic Grammar alternative, this follows from the considerably greater weight of linearization (40) over subcategorization (5) which compensates for the fact that TSat has a slightly higher weighting than linearity:

(83) *Blocking of dislocation by strong linearization* **Input:** rarahipa-ti$_{\text{CAUS}}$-→$_{40}$-(*σσ)$_5$cane(σ)$_1$

	MorphCtg ∞	Dep ↯ 10	Dep ∗ 10	TSat 4	Lin 3	$\mathcal{H}$
☞ a. rarahípa-ti-*σσcane(σ)				5+1		-24
b. rarahípa-ti-*σσcane		1		5		-30
c. rarahípa-cane-ti					40	-120

In our ongoing research, we investigate whether the Harmonic Grammar alternative can account for the full range of variation between reordering and compositional orderings found in the language.

6 Conclusions

In this paper, we have argued that non-compositional affix order in Rarámuri is due to phonological, not to morphological factors, partially in the form of prosodic wellformedness, and partially in the form of morpheme-specific prosodic subcategorization. We have shown that Gradient Symbolic Representations (Smolensky & Goldrick 2016) and virtual phonological structure in the sense of Lionnet & Rolle (2020) allow for establishing a natural link between possible ordering patterns and independent morphophonological properties of single affixes. If this approach turns out to be correct, it also raises the question whether other classical cases for morphotactic conditioning in affix order (e.g. the CARP template in Bantu, Hyman 2003, and the variable order of Tagalog reduplication, Ryan 2010) might also be amenable to a more phonological approach. On the other hand, our quantitative evaluation of the available Rarámuri data reveals that much of the empirical picture is still unclear or only substantiated by a small number of examples. Thus there is still plenty of work ahead both on the analytic and the empirical side.

Appendix

A Summary of Ranking and Weights

HomLin abbreviates Homomorphemic Linearity
MorCont abbreviates Morphological Contiguity

(84) *Stem-Level ranking*

HomLin	MorCont	1∗	3σ⊡	Con ↯	TSat	Lin	Max V	Dep ∗	Dep ↯	TSat	Lin	Lin	TSat

(85) *(Partial) Word-Level ranking*

HomLin	MorCont	1∗	3σ⊡	Lin	Lin	Lin	TSat	TSat	TSat	Con ↯	Dep ↯

(86) *Different degrees of subcategorization strength*

a. Weak subcategorization: -na∗leσ (Desiderative)
b. Medium-strength subcategorization: -simiσ (Associated Motion)
c. Medium-strength and *weak* subcategorization: ∗σσcaneσ (Evidential)
d. Strong subcategorization -∗σr (Causative)

(87) *Linearization strength of different affix pairs*

	APP	CAUS	DES	MOT	EV
APP	*				
CAUS		*			
DES			*		
MOT				*	
EV					*

B The lexical stress of roots

For the analysis of /-na(le)/ in section 3.4, it is crucial to determine if a root has underlying stress. Under Caballero's analysis, stressed roots keep their accent, independently of the accentual properties of Stem-Level affixes. Stressless roots have default stress on their second (or in the case of monosyllabic roots, their only) syllable in the absence of accented suffixes, but are stressless in the context of accented affixes. In the case of trisyllabic roots, stress is also either fixed on one of the three syllables (→ underlying stress) or alternates between 2nd (default) and 3rd syllable (before an accented affix

which shifts its accent to the root). Some roots which are bisyllabic on the surface have a similar shift between the 1st and the 2nd syllable. Following Bogomolets (2020), we take these to be stressless trisyllabic roots with a catalectic (segmentally empty) initial syllable.
As a consequence, the underlying stress can be determined (at least) in the following ways:

(87)

A root occurs without stress	→	stressless root
Stress alternates between different root positions	→	stressless root
A trisyllabic root has stress on different syllables depending on its suffixes	→	stressless root
A root maintains its stress in the context of a stress-shifting/accented suffix	→	stressed root
Stress on the 3rd root-σ before an unaccented suffix	→	stressed root
Stress on the 1st root-σ in a polysyllabic root	→	stressed root

The following table lists the evidence for classifying a verb root as stressed or unstressed from examples given in Caballero's publication. "??" indicates that the root has 2nd-syllable stress in all examples (which could be underlying or default stress), and there are no examples which would resolve this ambiguity.

			Evidence
anaca	'endure'	(unstressed)	with respect to stress (2. or 3.σ) (2011a:762:T-3)
awi	'dance'	(unstressed)	unstressed occurrence (2008:144:47-a)
bahí	'drink'	(stressed)	stressed before stressed -sá (2008:179:8-b)
húmisi	'take off (pl) '	(stressed)	stressed before stressed -má (2011a: 758:9-a)
íbi	'bring'	(stressed)	1st-σ stress before unstressed -ki (2010:186:31-c)
iki	'happen'	(unstressed)	unstressed occurrence (2008:434:3)
isí	'urinate'	(stressed)	stressed before stressed -sá (2008:179:8-c)
to	'take'	(unstressed)	unstressed occurrence (2011a:752:1-f)
koʔ	'eat'	(unstressed)	unstressed occurrence (2008:340:10-a)
koʔa	'eat'	(unstressed)	unstressed occurrence (2011a:763:16-c)
koci	'sleep'	(unstressed)	unstressed occurrence (2008:340:10-b)
nará	'cry'	(stressed)	stressed before stressed -ká (2008:426:30-a)
nári	'ask'	(stressed)	stress on first root-σ (2008:289:3-e)
pewa	'smoke'	(unstressed)	alternating stress (1. or 2.σ) (2011a:761:14-e)
pocí	'jump'	(stressed)	stressed before -ká (2022:579:57)
rarahípa	'run a race'	(stressed)	3rd-σ stress before unstressed -ti (2008:69:22-d)
rari	'buy'	(unstressed)	unstressed occurrence (2008:295:10-e)
raʔici	'speak'	(unstressed)	alternating stress (2. or 3.σ) (2008:119:17)
sú	'sew'	(stressed)	stressed before stressed -sá (2011a:762:T-3)
táni	'ask'	(stressed)	1st-σ stress before unstressed /-si(mi)/ (2010:178:21)
uba	'bathe'	(unstressed)	unstressed occurrence (2008:296:11-a)
wikará	'sing'	(stressed)	3rd-σ stress before unstressed /-si(mi)/ (2010:p.178:(21)
-bú	'remove'	(stressed)	stressed before stressed ká (2008:127:30-c)
atisi	'sneeze'	??	
koru	'feel like eating'	??	
mici	'carve'	??	
nako	'fist.fight'	??	
oʔpesi	'vomit'	??	
tore	'cackle'	??	

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