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TEMPLATIC ARCHITECTURE

ABSTRACT

Building on principles of Government Phonology, this paper explores a minimalist theory of projection. The two operations it postulates, *merge* and *label*, are formalized mathematically as multiplication and integration, respectively. Given this formalization, the syntactic interpretation of phonological entities can be understood as a morphism in the strict sense: a mapping that is structure preserving with respect to *merge*. The formalism is illustrated in the derivation of a simple, yet unexplained, condition on templates, exemplified with German *strong* verbs: a single templatic site cannot simultaneously host markers that correspond to distinct syntactic heads.

KEYWORDS

Morpho-phonology, algebraic syntax, German verbs.

Templates are prosodic configurations serving some specific morphological function. Does this function derive from properties of the prosodic configuration, from properties of the template (as a grammatical primitive), or from something else ?

In this paper, we endorse a bare phrase structure analysis of templates, strictly separating the derivation of syllabic constituents (*i.e.*, *prosody*) from the derivation of morpho-syntactic features (*i.e.*, *syntax*). Both are driven by a single generative engine, consisting of two operations : *Merge* and *Label*, both defined in simple mathematical terms. The morphological role of prosodic configurations, as described by templates, is a consequence of *interpretation* : objects in prosodic structure are mapped on sets of morpho-syntactic features (*i.e.*, syntactic heads). We outline this proposal in section 1.

Our account redefines the questions to be asked by a theory of non-concatenative morphology. Since both prosodic and syntactic structure is fully compositional, the question is no longer whether morphological processes are concatenative or not : non-compositional structures simply cannot be generated. The question to be addressed now is how prosodic and syntactic derivations converge in a given language, such that a structure-preserving mapping between the two domains is possible. If convergence is perfect, we observe templatic morphology. In section 2, we illustrate the mechanisms of our proposal with some classes of German verbs.

1. On Templates

1.1. Phonology

We assume the general framework of *Government Phonology* (Kaye, Lowenstamm & Vergnaud 1985, 1990), in which the melodic content of a phonological string is represented in the form of autosegmental elements. Since we are not concerned with melody in this article, we will informally talk of *segments* throughout. As for the representation of prosodic structure, we adopt the *CV model* (Lowenstamm 1996), the main assumptions of which are given in (1).

(1) <u>Conditions on syllabic constituents</u>
- a. There are only two syllabic constituents, *onset* and *nucleus*.
- b. Syllabic constituents do not branch.
- c. Onset and nucleus strictly alternate.

Since neither onsets, nor nuclei branch, there is a one-to-one correspondence between syllabic constituents and skeletal positions. Therefore, it is not necessary to separate timing units and syllabic constituents. The representations in (2a) are replaced by the simpler structures in (2b).

```
(2)                                Onset     Nucleus
   a.  constituent level:          O         N
                                   |         |
       skeletal level:             x         x
                                   |         |
       segmental level:            b         a

   b.  skeletal level              C         V
                                   |         |
       segmental level:            b         a
```

Under (1), there is only one syllabic type, a non-branching onset followed by a non-branching nucleus: CV. CV is the minimal unit at the skeletal level, C- and V-positions cannot be manipulated in isolation.

Of course, some patterns diverge from consonant-vowel sequences on the surface. They are represented as recursions of CV units that involve silent C- or V-positions. Long vowels and geminates are represented as in (3a) and (3b) respectively; (3c) gives an example of a syllable with a "branching onset" and (3d) shows how a "closed syllable" is represented.

```
(3) a. Long vowel: a:               b. Geminate: bb
       C V C V                          C V C V
         |/                             |/
         a                              b

    c. Branching onset: bra         d. Closed syllable: bar

       C  V  C  V                       C  V  C  V
       |     |  |                       |  |  |
       b     r  a                       b  a  r
```

The syllabic types in (3c) and (3d) have the same underlying structure: CVCV. The superficial differences between these types derive from the way segments are associated to the skeletal level, in (3c, d) the choice of the V-position to be spelled out[1].

The CV model allows straightforward generalizations over morphologically related words (Lowenstamm 1996). Consider as an example two verbal forms of the root √drb *'to hit'* in Classical Arabic (4) [2].

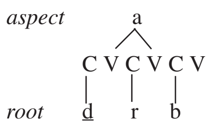
Under standard assumptions, the perfective stem *darab* and the imperfective stem *drib* have different syllabic structures. Therefore, one form can only be derived from the other by means of resyllabification. In the CV framework, no such operation is necessary. The only relevant distinction is that the V-position separating the first and second radical is spelled out in the perfective, and silent in the imperfective.

```
(4) a. Perf. 3ms: darab-a           b. Imperf. 3ms: ya-drib-u
       C  V  C  V  C  V                 C  V  C  V  C  V
       |  |  |  |  |                    |     |  |  |
       d  a  r  a  b                    d     r  i  b
```

In the CV model, the distinctions traditionally encoded in supra-skeletal syllabic structures are reduced to the distribution of empty V-positions. Where a classical syllabic model postulates the existence of two types of timing units, syllabic constituents and skeletal positions, the CV model requires only one of them, skeletal positions. It is therefore the null hypothesis. The postulation of any additional timing unit, like *morae*, *syllables*, etc., is a costly departure from the null hypothesis – to be avoided, unless required by substantial empirical facts.

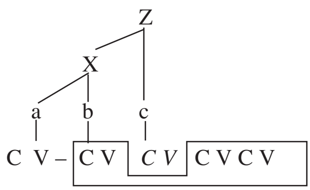
1.2. From the CV skeleton to syntactic heads

In order to represent the generalization that both the root and the vowel melody are morphemes, it is assumed since McCarthy (1979, 1981) that root consonants and vowel melody are represented on separate tiers, as in (5) for the perfective stem *darab*. Melody elements are associated to the C and V slots according to the principles of autosegmental theory.

(5)


(5) derives the independence of root and affix by separating vowels and consonants. If (5) is tenable, then templates are simply one form of concatenation, a highly welcome result.

Guerssel & Lowenstamm (1990) and Lowenstamm (2001) take such considerations further. On their assumptions, a template is composed of prosodic primitives, *i.e.* CV units, some of which may project morpho-syntactic nodes, as depicted in (6) [3].

(6)


The morphological theory underlying (6) differs fundamentally from previous ones. First, like McCarthy's (1979) structure, it offers the tools to account for a range of apparently non-concatenative markers in a fully compositional way. Second, it does so without stipulating additional theoretical apparatus: every primitive in Guerssel and Lowenstamm's account is firmly motivated in either phonology, or syntax. Finally and most importantly, the viability of this account opens the perspective to state a theory on the phonology-syntax interface that does not depend on late access to the lexicon. Implicit in (6) is the assumption that (complex) syntactic heads enter the derivation with all their features present, as it is assumed in standard minimalist theories like Chomsky (1995), but not, in many morphological theories (*cf*. Halle & Marantz 1993; Bobaljik 2001).

1.3. *Label*, *Merge*, and *Interpret*

(6) does not specify the operation that transforms a prosodic string into morpho-syntactic nodes. We claim such a direct transformation does not exist at all. Prosodic and syntactic structure is built separately in parallel, related only by means of *interpretation*. We will now propose a simplified mathematical formalism that derives both prosodic and syntactic structure, and then turn to the mapping that facilitates interpretation.

1.3.1. Headedness in prosody and beyond

Defining the prosodic structure of the template means identifying its head. The operation that defines headedness can be informally construed as an integration that takes as input an existing representation and delivers the head as output. This operation gets rid of information that does not correspond to the head. Since constituents are identified by their head, we call the head *label*, and the integration delivering the head *labeling* (*cf*. Chomsky 2001). In the following, we present the labeling operation in very elementary mathematical terms, which are just sufficient for our purposes.

Take a phonological string CVCVCV, *i.e.,* a string of three adjacent CV units. This string can be formalized as a function of three variables x, y, z, taking their values in finite domains X, Y, Z:

(7) $f_3 (x, y, z) = f(x)\, g(y)\, h(z)$

The function f_3 is given and defines the initial structure. It is written in a factored form, and indeed, only factored (or additive) forms are considered here.

By definition, the labeling operation consists in integrating the initial function, supposed to describe the initial structure, f_3 in (8), according to a given coordinate, say z:

(8) $f_2 (x, y) = \int_{z \in Z} f_3 (x, y, z)\, dz,$

$\text{with} \int_{x \in X} f(x)\, dx, \quad \int_{y \in Y} g(y)\, dy, \quad \int_{z \in Z} h(z)\, dz \neq 0$

For example, if we choose $f_3 (x, y, z) = xyz$, we get:

(9) $f_2 (x, y) = \int_{z \in Z} f_3 (x, y, z)\, dz = xy \int_{z \in Z} z\, dz = C\, xy$

For $0 < C < \infty$, this application can be seen as the projection P from E (R^3), the set of functions f_3, into E (R^2), the set of functions f_2.

For simplicity, the equations in (8) and (9) are expressed for continuous variables and functions. However, the formalism can easily be applied to discrete sets by summing over a finite set instead of integrating, to read:

(10) $f_2(x, y) = \sum_{z \in Z} f_3(x, y, z) = f(x)\, g(y) \sum_{z \in Z} h(z) = C\, f(x)\, g(y)$

C is a constant that does not depend on x, y. It has only numerical relevance.

The labeling operation gets rid of the information contained in the z-axis; it replaces it by a constant. (10) yields the structure in (12a). We now sum according to y and get:

(11) $f_1(x) = \sum_{y \in Y} f_2(x, y) = D\, f(x)$

An appropriate choice of integrating devices can be made such that all constants are equal to 1, delivering the *Inclusiveness Condition*: no new entities are introduced during derivations[4].

(10) delivers the structure in (12a); together with (11), we get (12b).

```
(12)  a.  x    y              b.  x                    level3
          |    |                  |
          x    y    z             x    y               level2
                                  |    |
                                  x    y    z          level1
```

We have built the structures in (12) bottom-up, from level 1 to level 2, and from level 2 to level 3, by summing according to one axis. Now we want to check if this operation is structure preserving with respect to the operation *Merge*, which assembles objects to form constituents (*cf*. Chomsky 1995).

We define *Merge* as μ_1: $\mu_1(x, y) = xy$. For $f_3(x, y, z) = \mu_1(x, y)\, z$, (10) yields:

$\mu_2(x, y) = \sum_{z \in Z} xyz = K\, xy$, and this is *Merge* again.

The operation μ_2 that associates components at level 2 has the same properties as the one that associates components at level 1: $\mu_2 = K\mu_1$ where K is a constant. Informally speaking, the operation μ_2 that merges the 2 CV units at the output level has the same properties as the one that merges the 3 CV units at the input level, μ_1. Labeling is thus structure preserving with respect to *Merge*.

1.3.2. Mapping into syntax

Metaphorically speaking, summing according to one variable filters out parts of an existing representation, and thereby defines headedness. It is thus narrowly constrained to a given domain, in the present case phonology. However, language crucially establishes relations between different domains: expressions in one domain have an *interpretation* in another domain.

We represent *Interpretation* as a linear mapping, which is defined as follows:

(13) Let V, U be linear spaces over the same field K. A mapping I: V - > U is a *linear mapping*, or a *homomorphism over linear spaces* if
$\forall u, w \in V, I(u + w) = I(u) + I(w), \forall k \in K, \forall v \in V, I(kv) = kI(v)$

Put informally, a linear mapping is structure preserving in the sense that addition and multiplication maintain their properties in the final space. Under the assumption made above that *Merge* can be formalized as a product, *Interpretation* *I* is structure preserving with respect to *Merge*. Notice that the final space of *I* is not a sub-structure of, but distinct from the original space.

1.4. Full and partial interpretation

Take a tri-radical root, associated to a phonological string $CV_1CV_2CV_3$, structured by (10) and (11) as in (12b), yielding (14).

(14)

CV_1	Π_2
CV_1CV_2	Π_1
$CV_1CV_2CV_3$	terminal level

The structure in (14) allows three applications of the *interpretation* mapping, at the terminal level, at Π_1, and at Π_2. In principle, a tri-radical stem can thus encode three sets of morpho-syntactic features.

Tri-radical stems do not always encode that many features. Regular stems in the well known Indo-European languages usually encode just two sets, conceptual and categorial features. This means that *interpretation* is optional: some elements in the initial space are mapped on the identity element, *i.e.*, the integer 1 in the present case. We will informally write that an element lacks an interpretation, when it is mapped on the identity element.

Assume our tri-radical root in (14) is realized as a verb, and that its syntactic context includes the heads V, v and Infl[5]. The two options we will be concerned with below are *interpretation* of all prosodic levels, *i.e.,* perfect convergence between prosodic and syntactic structure, as depicted in (15a), and partial interpretation, *i.e.,* imperfect convergence, as depicted in (15b).

(15)

a. *full interpretation* $\rightarrow$ *templatic inflection*			b. *partial interpretation* $\rightarrow$ *affixal inflection*		
$C V_1$	~ >	I	$C V_1$	~ >	v
$C V_1 C V_2$	~ >	v	$C V_1 C V_2$	~/~ >	
$C V_1 C V_2 C V_3$	~ >	V	$C V_1 C V_2 C V_3$	~ >	V

2. Why German Causatives Are *Weak*

To illustrate how this proposal generates new predictions, let us go through one example in some detail. Standard German (SG) has a class of verbs that inflect by means of stem vowel alternation. Those verbs have been called *strong verbs* by Grimm (1819).

SG strong verbs exhibit various, interacting stem-vowel alternations. Causativization illustrates this interaction most clearly : stems that inflect by stem-vowel alternation (*i.e.*, are *strong*) in their base form require a tense affix (*i.e.*, are *weak*), once the verb is causativized by stem-vowel alternation. That is, causativization blocks alternation for tense.

2.1. Alternations

2.1.1. Causativization versus *tense*

Take the strong verb *springen* 'to jump' in (16a). The corresponding causative verb *sprengen* 'to blow up' in (16b) is weak : its past tense vowel is identical with its present tense vowel, and tense is marked by the suffix *-te*.

(16)

	a. strong verb :			b. causativized verb :		
	infinitive	*past 3sg*	*gloss*	*infinitive*	*past 3sg*	*gloss*
	spr**i**ngen	spr**a**ng	*jump*	spr**e**ngen	spr**e**ng-te	*blow up*
	past tense ablaut			*no ablaut*		

Causativization by vowel alternation is an unproductive rule affecting, among other classes, a subset of strong verbs. Several melodic realizations of the alternation can be observed, some of which are given in (17).

(17)

a. strong verb :			b. causativized verb :		
infinitive	*gloss*	*stem V*	*infinitive*	*gloss*	*stem V*
sitzen	*sit*	**I**	setzen	*put*	**A. I**
dringen	*penetrate*	**I**	drängen	*push*	**A. I**
fallen	*fall*	**A**	fällen	*fell*	**A. I**
fahren	*drive*	**A**	führen	*lead*	**U. I**
fliessen	*flow*	**I**	einflössen	*fill sb with sth*	**A.U.I**

Causativized verbs are weak : they do not show any vowel alternation between present stem and past stem, tense is expressed by the suffix *-te*.

(18)

present 3sg	*past 3sg*	*gloss*
setzt	setzte	*put*
drängt	drängte	*push*
fällt	fällte	*fell*
führt	führte	*lead*
flößt ein	flößte ein	*fill sb with sth*

2.1.2. Tense and mood

Alternations with distinct morphological function do not altogether exclude each other. Strong stems form their conditional (or *past subjunctive*) by an alternation on the basis of the past tense vowel, as exemplified in (19): the element I is added to the vocalization of the past indicative.

(19)	*inf.*	*past 3sg*	*cond. 3sg*	*gloss*
	heb-en	hob	höb-e	*lift*
	A. I	A. U	A.U.I	

In sum, past tense marking by vowel alternation seems to be compatible with mood-marking by vowel alternation, but incompatible with causativization by vowel alternation. On any account known to us, incompatibilities of this kind must be treated as a coincidence and therefore, a mystery.

2.2. Analysis

In the framework sketched here, a given alternation, or indeed any melodic element, cannot be a marker of a morpho-syntactic category itself. Melodic elements are just what they are at face value: melodic elements.

The question our framework forces us to ask is whether a given entity in prosodic structure can be mapped on an entity in syntactic structure. Correspondingly, we are lead to ask a second question: are the morpho-syntactic features we want to encode by distinct alternations on a single site members of a single set of features? In other words, do all alternations hosted by a given prosodic entity encode features of a single syntactic head?

Our prediction is that any single prosodic entity may not host alternations that attempt to encode features of distinct syntactic heads. This prediction is directly borne out by the data: *conditional* is arguably a feature of the tense node (*cf.* Iatridou 2000). Therefore, alternations encoding mood and tense are expected to coincide at a single site.

(20)
```
C V              ~ > I [past, cond]
C V C V          ~ > v
C V C V C V      ~ > V
|  |/       |
h  ö        b
```

By contrast, the causativization alternation encodes an argument structural property that is standardly related to the syntactic head v. Once a given prosodic entity is mapped on v, it cannot be mapped on I. Thus the incompatibility.

(21)
```
C V              ~ > v [caus]
C V C V          ~ > v
C V C V C V      ~ > V            C V   ~ > I [past]
|  |  \__|                        |  |
f  ä      l                       t  ∂
```

3. Conclusion

To summarize, we have proposed a theory of the syntax-morphology interaction that aims at following minimalist guidelines. It strictly separates derivations in different domains, thereby reducing computational burden. It also limits itself to minimal assumptions regarding derivational technology, defining operations in simple, mathematical terms. After having illustrated the mechanisms of this theory with a simple example from German, there remains one substantial empirical challenge : the investigation of the more complex templatic systems in Afro-Asiatic languages, under the new perspective.

NOTES

1. The spell-out of empty vocalic positions is governed by the local environment under conditions defined in the *Empty Category Principle*, *cf*. Kaye, Lowenstamm & Vergnaud (1990), Lowenstamm (1996, 1998) for details.
2. Underlining indicates emphatic articulation.
3. Root consonants attach to boxed positions ; *a* is a categorial affix, *c* an inflectional affix, *X* and *Z* are syntactic heads.
4. Notice that inverting (10) and (11) is, in general, very difficult, hinting at a radical version of Chomsky's Phase Impenetrability Condition.
5. We use the generic label 'Infl' for an inflectional head, without commitment to specific assumptions regarding its feature content.

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RÉSUMÉ

En se fondant sur les principes de la Phonologie du Gouvernement, cet article présente une théorie minimaliste de la projection. Deux opérations, *merge* et *label*, sont postulées et formalisées en termes mathématiques – soit, respectivement, la multiplication et l'intégration. Dans le cadre de cette formalisation, l'interprétation syntaxique des entités phonologiques peut être comprise comme un morphisme au sens strict, c'est-à-dire une application préservatrice de structure par rapport à *merge*. Ce formalisme permet de dériver une condition simple, mais inexpliquée, sur les gabarits des verbes forts de l'allemand : un site gabaritique unique ne peut pas être l'hôte de marqueurs qui correspondent à des têtes syntaxiques distinctes.

MOTS-CLÉS

Morpho-phonologie, syntaxe algébrique, verbes allemands.