Minimalist Morphology*

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Minimalist Morphology (MM) is a lexical approach to morphology which was developed in the early 1990s within the research cluster *Theory of the lexicon* at the University of Düsseldorf (Germany). Starting with a paper on the inflectional morphology of German by its main protagonist Dieter Wunderlich (Wunderlich 1992), MM has mainly covered aspects of inflectional morphology (the role of paradigms, the analysis of inflectional affixes and inflection classes, stem allomorphy, the hierarchy of functional categories, voice phenomena, inventories of case markers and pronominal affixes), but has also dealt with clitics and clitic sequences and some aspects of derivational morphology (e.g., nominalization, sequence of diathesis markers). Early on MM was supplemented by a lexical theory of agreement (Wunderlich 1994, Fabri 1993) and a lexical theory of argument structure and argument linking (*Lexical Decomposition Grammar* = LDG; Joppen & Wunderlich 1995, Wunderlich 1997, Stiebels 2002).

The 'Minimalist' notion was developed independently and without any close relation to *Minimalist Syntax* (Chomsky 1993). Since MM takes syntax and morphology to be autonomous and qualitatively different modules of grammar (see Wunderlich & Fabri 1995, Wunderlich 2008 for a discussion of the differences), it does not integrate syntactic notions of *Minimalist Syntax* into morphology. However, it shares the basic idea of economy of derivation and representation. A major goal is to provide analyses based on minimal inventories of forms and minimal entries of morphemes, both of which are learnable and require a minimal number of operations.

According to Stump's (2001) classification of theories of inflection, MM represents a lexical-incremental approach to inflection. Morphemes are treated as lexical items and understood as signs, pairing a Phonetic Form (PF) with a Semantic Form (SF) or a decomposed feature matrix. Given the fact that other frameworks with a sign-based architecture (e.g., *Head-Driven Phrase Structure Grammar*; Pollard & Sag 1994) allow for morpheme-based analyses (e.g., Krieger & Nerbonne 1993) as well as word-based analyses (e.g., Riehemann 1998), it should be emphasized that MM pursues a strict morpheme-based strategy. In contrast to more phonology-driven (Anderson 1992) or syntax-driven approaches to morphology (e.g., *Distributed Morphology*, DM; Halle & Marantz 1993, ??? this volume), MM's analysis of morphological complexes is grounded in semantic terms. The proposed lexical representations of stems and affixes are based on Bierwisch's (1983) two-level approach to semantics, which distinguishes between SF and Conceptual Structure (CS).

The starting point for MM is the assumption that the core of morphology is concatenative in form and compositional in meaning – without failing to acknowledge non-concatenative or non-compositional morphology. MM views morphology as an autonomous generative component of grammar that takes lexical items (stems and affixes) as input and projects morphologically complex elements into syntax. In this regard, MM differs from post-syntactic accounts such as DM. As a lexical theory MM advocates the *Lexical Integrity Principle* (Bresnan & Mchombo 1995), which excludes any syntactic manipulation of word-internal material.

1. Derivation vs. inflection

MM does not make any categorical distinction between inflection and derivation, thus rejecting the split-morphology hypothesis (e.g., Anderson 1982); inflection and derivation are both assigned to

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the morphology module. There are a few minor differences in the analyses of so-called inflectional and derivational morphemes: inflectional morphemes are always analyzed as heads, whereas some derivational morphemes are exempted from head status (e.g., prefixes and verbal particles in German; see Wunderlich 1987, Stiebels 1998). Besides the well-known fact that only derivational morphemes may shift the lexical category of their base, MM also takes the property of argument structure alteration of the base as an identifying feature of derivational morphology (e.g., causative morphemes, which introduce an agent argument into the verb). Inflectional morphology only specifies the properties of the arguments of the base; verbal inflectional morphology, for instance, usually targets the situational variable of the verb (e.g., tense morphology) or the individual arguments of the verb (agreement morphology). That derivational morphology often exhibits richer semantic content than inflectional morphology is reflected in MM's lexical representations of the respective morphemes.

Affixation yields candidate forms both for inflection and derivation, which may be subject to further wellformedness constraints. The major difference between inflection and derivation lies in the role of paradigms. Although one may think of certain derivational morphemes as bearing paradigmatic structure (if they build a set of forms with equal function), these forms are never organized in the way that inflectional forms are, where certain paradigm principles obtain which guarantee unique forms for each paradigm cell (see section 3). By its paradigmatic organization, inflectional morphology filters projection into syntax (see (1)); this property is lacking in derivational morphology:

(1) The inflectional system of MM

$$
\begin{array}{cl}
\boxed{\text{stems and affixes}} & \\
\Downarrow & \}\ \text{affixation} \\
\boxed{\text{candidate word forms}} & \\
\Downarrow & \}\ \text{selection} \\
\boxed{\text{paradigms}} & \\
\Downarrow & \}\ \text{projection} \\
\boxed{\text{syntax}} &
\end{array}
$$

MM treats regular and irregular morphology differently; the latter is not accounted for by specific (readjustment) rules, but by specific lexical representations. Evidence for this distinction also comes from psycholinguistic studies (see the overviews by Clahsen 2006 and Penke 2006). Irregular morphology that is based on stem allomorphy is discussed in section 5.

1.1. Lexical representations

Inflectional morphemes minimally include a PF-representation, a specification of the base's category, and an output specification. Forms that are necessarily bound (affixes or items that only surface as roots) are designated as [+min] (Stiebels & Wunderlich 1994) in their morphological characterization (MORPH). The second person singular marker *–st* in German thus has the entry in (2). It attaches to verbs and contributes the specification [+2]. The slash notation in (2) should be read as 'output/input'.

(2) /st/; [+min]; [+2]/+V

An alternative representation is given in (3a). Here, the information concerning the base is more elaborate, indicating its theta-structure (TS) and its SF. TS is written as a sequence of λ-variables, which abstract over the variables in SF. P denotes a predicative argument and s denotes the situational variable, while the other lower-case variables represent individual arguments. Agreement features and morphosyntactic features relating to the world-time parameter of the situational variable are annotated as indices on the λ-variables. The German past tense suffix *-t(ə)* is represented in (3b). The semantic specification of the feature [+pret] is encoded on SF – with t_0 denoting the time of utterance and t(s) the time of the situation. Since inflectional affixes do not shift the category of their base, the output category can remain unspecified.

(3)		PF	MORPH	TS	SF
	a.	/st/;	[+min];	$\lambda P_{[+V]}\ \lambda x^{<+2>}\ \lambda s$	P(x)(s)
	b.	/tX/;	[+min];	$\lambda P_{[+V]}\ \lambda s^{<+pret>}$	$[P(s)\ \&\ t(s) < t_0]$

Note that MM takes markedness of exponence at face value. This means that features and feature values are chosen on the basis of existing morphological exponents. A morpheme is usually lexically specified as the positive-valued instance of the respective feature (e.g., [+plural], [+feminine] or [+past]). Negative feature values are taken as default specifications that arise from lexical underspecification of the respective morphemes. Only in rare cases do morphemes bear a negative (output) specification (e.g., the English present tense agreement morpheme *-s* [–1,–2]).

The lexical representation of derivational morphemes does not differ fundamentally from that of inflectional morphemes. Affixes deriving agent nominals (e.g., *kill-er*) are represented as in (4a), and affixes deriving instrument nominals (*open-er*) as in (4b).

(4)		PF	MORPH	TS	SF	
	a.	/er/;	[+min]; [+N]	$\lambda P_{[+V]}\ \lambda x\ \exists s$	P(x)(s)	(agent n.)
	b.	/er/;	[+min]; [+N]	$\lambda P_{[+V]}\ \lambda u\ \exists x\ \exists s$	[INSTR(u)(s) & P(x)(s)]	(instrument n.)

The nominalizing morpheme of agent nominals induces a category shift and the existential binding of the situational variable of the underlying verb; in instrument nominals a new referential argument is introduced by the nominalizing affix. This argument is integrated via an INSTR-relation. In both cases stems and affix are composed via Functional Composition, which leads to argument inheritance (see Stiebels 1999 for analogous analyses of Nahuatl nominalizations).

1.2. Overt vs. covert exponence

MM does not assume any zero morphemes in inflection. If certain paradigm cells cannot be filled by a combination of the stem with overt affixes, the respective stem will serve as a candidate (see below). In cases of covert category shifts (conversion), MM makes use of templates that are associated with an abstract verb. This can be illustrated with denominal verbs in German or English (see Wunderlich 1987, Kiparsky 1997 and Stiebels 1998 for details). In these cases the verb receives its PF from the base noun, which is semantically integrated into an abstract verb that is associated with a template. Based on the observation that the attested patterns of denominal verbs are cross-linguistically quite uniform, only a small set of universal verbal templates needs to be postulated. The choice of the template depends on the sort and the canonical use of the nominal referent (Wunderlich 1987, Kiparsky 1997). Denominal verbs are subject to the structural constraint that the base noun has to be incorporated as the lowest argument of the template, which can be stated as the *Principle of Lexical Incorporation*.

(5) *Principle of Lexical Incorporation* (Stiebels 1998:273)
The base noun in a denominal verb as well as the base adjective in a deadjectival verb can only saturate the lowest-ranked argument of a template.

The derivation of cross-linguistically common location verbs is illustrated in (6). Here, the base noun specifies the relatum/ground argument of a local relation. The predicative role P is filled by the base noun.

(6) Location verbs (e.g., *schultern* 'shoulder')
a. $[\ ]_V$: λP λy λx λs ∃z [CAUSE(x, BECOME(LOC(y,ON[z]))) & P(z)](s)
b. $[\text{/shoulder/}]_V$ λy λx λs ∃z [CAUSE(x, BECOME(LOC(y,ON[z]))) & SHOULDER(z)](s)

2. Affixation

MM generally assumes that stems and affixes may be combined freely. The combination is only restricted by potential input specifications of affixes and the following principles:

(7) Principles of affixation (Wunderlich 1996:97)
a. MONOTONICITY: The output of affixation must be more informative than the input.
b. ADJACENCY: The input requirement of affixes must be met locally.
c. AFFIX ORDER: The order of affixes must conform to the hierarchy of functional categories, i.e., affixes that express lower-ranked categories must be attached first.

MONOTONICITY ensures that no information is deleted via affixation; there are no rules that would resemble DM's impoverishment rules. Moreover, MONOTONICITY rules out vacuous or redundant affixation. Ortmann (1999) has shown that certain alleged cases of redundant affixation turn out to be non-redundant under closer scrutiny.

ADJACENCY, the morphological implementation of a locality constraint, requires that affixes attach directly to stems that bear the respective input specification; intervening morphemes are ruled out as illustrated in (8): AFF_2 may not intervene between STEM and AFF_1 because $[+\alpha]$ would become invisible.

(8)
a. AFF_1: $[+\beta]/+\alpha$
b. AFF_2: $[+\gamma]$
c. STEM $[\ldots, +\alpha]$
d. $^*\text{STEM-AFF}_2\text{-AFF}_1$ $[[[\ldots, +\alpha]\ +\gamma]\ +\beta]$

The linearization constraint AFFIX ORDER is formulated with respect to inflectional morphology and refers to Wunderlich's (1993) semantic foundation of the hierarchy of functional categories observed by Bybee (1985) and others. It implies that an affix expressing a lower-ranked category must appear closer to the stem than an affix expressing a higher-ranked category. The hierarchy is shown in (9). C encompasses markers of sentence mood.

(9) C > person > number > gender > mood > tense > aspect > voice (> verb)

Note that (9) puts an extrinsic ordering on competing candidate forms. For instance, a number marker cannot be put onto a form that bears a person marker or is otherwise specified for person. All categories that remain unmarked get a default interpretation (i.e., are negatively specified).

In general, MM subscribes to the view that in the ideal case, morpheme orders are determined by semantic scope – if there is a scopal relation between the elements involved:

(10) Morpheme orders must reflect semantic composition and scopal requirements of the morphemes involved.

This assumption, also advocated in Stiebels (2003), is in line with proposals by Muysken (1986) and Rice (2000). If certain morphemes do not enter into a scopal relation, their order is often arbitrarily fixed in the respective languages. These are typical instances in which language-specific morphological linearization constraints come into play. Moreover, MM also acknowledges that prosodic constraints may affect morpheme orders (see Caballero 2010 for examples). Since MM does not derive morphologically complex forms in syntax, Baker's (1985) *Mirror Principle* has to be reformulated. Its application domain is covered to a large extent by (10); however, there are cases in which two potential morpheme orders (A-B vs. B-A) do not differ in semantic terms, but yield different results for the syntactic projection of the respective item. One case in question is the combination of causative and passive: if passive applies first, the agent argument of the base verb cannot surface as a structural argument of the causativized verb; in the reverse order, this is possible (see Stiebels 2003 for details). The *Mirror Principle* can be confined to such cases and be reformulated as follows.

(11) *Mirror Principle* (revised): Morpheme orders must reflect the syntactic projection potential of the respective items.

The interaction of semantic, prosodic, morphological and quasi-syntactic constraints in determining morpheme orders suggests a treatment within *Optimality Theory* (OT; Prince & Smolensky 1993) or *Correspondence Theory* (CT; McCarthy & Prince 1995). So far, there is no thorough CT-based analysis of morpheme orders within MM (but see the use of linearization constraints in Wunderlich 2001a, section 6.2). The transparency of morpheme orders is weakened if prosodic and morphological constraints overrule (7c), (10) and (11). Whereas such a hybrid approach is compatible with MM's overall philosophy, templatic approaches to morpheme orders (i.e., position classes, see Inkelas 1993, Stump 1993a, Nordlinger 2010) are not. Templates are considered too powerful; they can stipulate any order and treat transparent and opaque substrings alike. Moreover, position classes do not provide any explanation for discontinuous dependencies and the complementary distribution of certain morphemes, nor is it evident whether they have any psychological reality; the full templatic structure is rarely exhausted in the respective languages.

3. Paradigms

In MM's view paradigms fulfill an important filter function, working as an interface between inflectional morphology and syntax. The members of a paradigm are complete word forms, which can be projected into syntax. Paradigms result from the combinatory force of inflectional morphemes, which define the dimensions of the paradigm by way of their lexical specification. In order to avoid massive overgeneration of word forms, the output of the free concatenation of morphemes must be constrained in various respects. MM assumes the following paradigm principles:

(12) Paradigm principles (Wunderlich 1996:99)
  a. COMPLETENESS: Every cell of a paradigm must be occupied.
  b. UNIQUENESS: Every cell of a paradigm is uniquely occupied.

UNIQUENESS enforces a competition between potential candidates of a certain paradigm cell, which has to be restricted by further constraints, whereas COMPLETENESS brings in default morphemes or unmarked forms (= stem forms) as fillers of certain paradigm cells. Note that COMPLETENESS does not rule out cases of paradigmatic gaps that are motivated by external factors (e.g., semantic or prosodic constraints); see also Baerman & Corbett (2010). Since MM's selection principles for paradigms relate to the entries of the respective morphemes and since MM relies on radical underspecification, underspecification is discussed first.

3.1. Syncretism and underspecification

Radical underspecification serves three purposes: a) it minimizes lexical entries, b) it accounts rather elegantly for systematic syncretisms (Stump's 2001 notion of "unstipulated syncretism"), and c) it makes empirically founded predictions for substitutions of forms.

Property (a), which aims at economy of representation, is implemented in MM by leaving out information that represents default information – typically those categories that remain unmarked in natural languages (e.g., singular, present tense, indicative, etc.). In a subject-agreement paradigm such as (13) the information [–pl] can be omitted. Moreover, the person/number specification of 3rd person can remain unspecified. As a consequence, the marker for 3rd person singular only specifies its operative dimension.

(13)

	SG	PL
1	*a*	*e*
2	*b*	*f*
3	*c*	*g*

Representation of affixes

/a/	[+1]	/e/	[+1,+pl]
/b/	[+2]	/f/	[+2,+pl]
/c/	$[\ ]_{pers}$	/g/	[+pl]

With respect to property (b), the nature of the syncretism determines MM's analytical choice between underspecified entries or disjunctive entries. Stump's (2001) type of "symmetric syncretism" would be an instance of the latter. Here, the homophonous forms cannot be traced back to a common function. In the verbal paradigm of German in (14), the plural marker *-n* can be analyzed as an instance of a natural syncretism, whereas the marker *-t* does not fill a natural class of paradigm cells and requires distinct entries or a disjunctive specification. The representation of the affixes is taken from Wunderlich & Fabri (1995); the shaded cells are confined to present tense indicative:

(14) German: present tense paradigm

	SG	PL
1	*-ə*	*-n*
2	*-st*	*-t*
3	*-t*	*-n*

Representation of affixes

/t/	[+2,+pl]	/X/	[+1]/–pl,–subj,–pret
/n/	[+pl]	/t/	[ ]/–pl,–subj,–pret
/st/	[+2]		

The massive overgeneration of candidate forms, which results from such minimal entries, is constrained by various selection principles discussed in the following subsection.

The second entry of *-t* is that of a default affix. As discussed by Wunderlich (in press), the default affix can be chosen on the basis of its extension (the form that covers most paradigm cells) or on the basis of its specification, i.e., whether it includes the most unmarked paradigm cell. In (15a) affix *b* should be the default affix under the extension criterion (with the disjunctive specification [+f ∨ +g]), whereas affix *a* should be the default affix under the inclusion criterion (with [–f,–g] being the most unmarked paradigm cell). In (15b) both criteria favor affix *a* as default affix. The inclusion criterion provides a stronger notion of default.

(15) Hypothetical paradigms

a.

	–g	+g
–f	*a*	
+f		*b*

b.

	–g	+g
–f	*a*	
+f		*b*

The two types of directional syncretism discussed by Stump (2001), i.e., unidirectional and bidirectional syncretism, are analyzed in MM by means of underspecification – if plausible – or disjunctive specification. *Rules of referral*, which are evoked by Stump (1993b, 2001) and others in these cases, are rejected by MM. As argued in several places (Wunderlich & Fabri 1995, Wunderlich 1996, 1997, 2004) such rules are quite problematic from the learner's perspective because they presuppose an order of acquisition of items that mirrors the direction of referral. Wunderlich (1996) provides an alternative account to Stump's analysis of the Macedonian verbal paradigm based on *rules of referral*. Likewise, Wunderlich (2004) reanalyzes the alleged unidirectional and bidirectional syncretism in Russian noun morphology as cases of underspecification.

Property (c), the substitution of marked forms by less marked forms, is especially evident in case markers and pronominal affixes. Here, MM uses features developed in LDG. Structural arguments and their respective linkers are distinguished by the features [±hr] 'there is a higher role' and [±lr] 'there is a lower role.' These features refer to the abstract argument hierarchy, which is derived from the lexical decomposition of the respective items. An intransitive verb has a single argument with the specification [–hr,–lr], and a ditransitive verb has three arguments with the specifications [+hr,–hr], [+hr,+lr], [–hr,+lr]. Dative case (DAT) and dative-like agreement (D) represent the most specific linkers; nominative case (NOM) and nominative-like agreement (N) represent the default linkers. Genitive differs from ACC in its categorial input specification.

(16) Lexical specification of structural linkers

case	agr	
DAT	D	[+hr,+lr]
ERG	E	[+lr]
ACC	A	[+hr]
GEN	P	[+hr]/+N
NOM	N	$[\ ]_{role}$

If more specific markers are blocked in certain syntactic contexts, less specific markers may substitute for the expected form. NOM is compatible with all argument roles, while DAT may be substituted by ACC or ERG. As a consequence, a lexical item lacking a distinct ACC form in its paradigm will surface in its NOM form in ACC contexts, which is typically the case for neuter nouns in Indo-European languages. The same kind of substitution applies if an ACC marker is in principle available, but blocked in certain contexts (e.g., if it may not occur on unspecific objects). Note that this form of underspecification can also account for cross-categorial syncretism of linkers (e.g., the identity of object and possessor agreement; see Stiebels 2002 for further details). In such overlaps, the linkers are not confined to one functor category.

3.2. Paradigm selection principles

Underspecification does not work without additional constraints that exclude massive overgeneration of forms. MM assumes the following selection principles:

(17) Selection principles (Wunderlich 1996:99)[1]

a. OUTPUT SPECIFICITY: Word forms with more feature specifications take precedence over those with fewer feature specifications.

b. INPUT SPECIFICITY: Word forms with underlying (lexically specified) feature values take precedence over those with derived values.

c. SIMPLICITY: Strings made of fewer affixes take precedence over those made up of more affixes.

OUTPUT SPECIFICITY and INPUT SPECIFICITY are implementations of the well-known *Elsewhere Principle*. OUTPUT SPECIFICITY guarantees, for instance, that in German verbal inflection 2nd person plural is marked by *-t* ([+2,+pl]) and not by *-n* ([+pl]). INPUT SPECIFICITY ensures that stems that already fulfill the input specification are given preference over forms that are derived by affixation. Strong verbs in German represent a case in point (see also section 5). Here, the preterite stem should be chosen (e.g., *warf* [+pret] 'threw'), not a combination of the base stem and the regular preterite suffix (here *werf-te*).

SIMPLICITY is relevant in cases in which a single morpheme has the same featural specification as a combination of separate morphemes. In German the paradigm cell for 2nd person plural could be filled by the suffix *-t* ([+2,+pl]) or the combination of *-st* ([+2]) and *-n* ([+pl]); SIMPLICITY selects *-t* as the optimal form. Sometimes, SIMPLICITY does not suffice to exclude unwanted forms. In the paradigm in (18) the plural marker *-n* needs an input specification in order to prevent the use of the complex form *-n-t* in 2nd person plural. Alternatively, one would have to assume three entries for *-t*.

(18) Low Franconian dialect (Cleves): present tense paradigm

	SG	PL
1	*Ø*	*-ə*
2	*-t*	*-t*
3	*-t*	*-ə*

Representation of affixes

/t/ [+2]
/ə/ [+pl]/–2
/t/ [ ]/–1,–pl,–subj,–pret

(18) also shows that the presence of a paradigm cell without an overt exponent requires blocking of the default morpheme by corresponding input specifications.

4. Inflection classes

MM rejects the idea of arbitrary inflection classes. Instead, it takes a learner's perspective and assumes that inflection classes are determined by phonological, prosodic properties (e.g., theme vowels, stem-final segments) or by morphosyntactic features such as gender (Wunderlich 1996, 2004, Steins 1998). No look-up of certain paradigm cells is required to specify the inflection class (in contrast to Wurzel 1984, Carstairs-McCarthy 1994). Wunderlich illustrates how the Russian system of nominal morphology can be accounted for without arbitrary labels. He inverts the perspective taken by Corbett (1991), who derives gender assignment from inflection classes, and assumes that Russian inflection classes result from gender and phonological features. Class 2 thus has a floating vocalic segment (annotated here as '[a]]'), while class 3 has a final palatal feature (PAL).

1 There is a further selection principle in MM, namely REDUCTION, which only plays a role in forms with disjunctive specification (see Wunderlich 1996).

(19) Identifying features of Russian inflection classes (Wunderlich 1996, 2004)

	Example		Gender	Phonological Context
class 1	*stol*	‘table’	masculine	C]
class 2	*kárta*	‘map’	feminine	^{a}]
class 3	*dver’*	‘door’	feminine	PAL
class 4	*slovo*	‘word’	neuter	

Inflectional markers of Russian then specify gender and/or phonological features as input conditions, as shown for the plural markers in (20); see Wunderlich (2004:381). The ACC/GEN plural marker of classes 2 and 4 is actually analyzed as a morphological condition (the form has to end in a consonant, thus blocking the thematic vowel):

(20) Russian plural markers (Wunderlich 2004)

a. NOM plural markers

/y/	[+pl]	(classes 1, 2 and 3)
/a/	[+pl], neuter	(class 2)

b. ACC, GEN plural markers

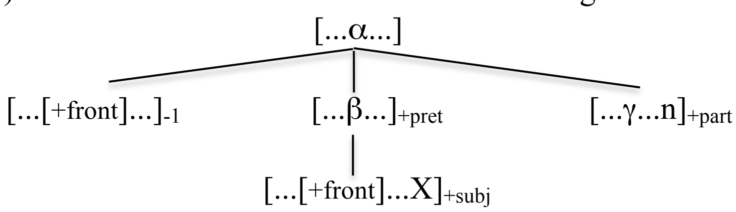
/C]/	[+pl,+hr], ^{a}] ∨ ^{o}]	(classes 2 and 4)
/ej/	[+pl,+hr], PAL]	(class 3)
/ov/	[+pl,+hr]	(class 1)

5. Stem allomorphy

Whereas productive stem allomorphy may be accounted for by rules, unproductive stem allomorphy is part of irregular morphology and is thus analyzed in MM by means of specific lexical entries. The respective stems may freely enter into the generation of word forms. Their combinatorial potential is determined either by their featural specification or by their prosodic makeup. The first pattern can be observed in strong verbs in German (Wunderlich & Fabri 1995), and the second pattern in Hungarian stem allomorphy (Stiebels & Wunderlich 1999).

Strong verbs in German differ in their number of stem allomorphs. Many strong verbs exhibit a distinct preterite stem ([+pret]), subjunctive stem ([+subj]) and participle stem ([+part]). Some verbs also exhibit a distinct stem for 2nd and 3rd person singular present tense. The distribution of stems exhibits certain subregularities that can be grasped by inheritance trees, in which subtrees inherit properties from the mother node. Wunderlich & Fabri have proposed the generalized inheritance tree in (21a): α, β and γ are abstract vowel features. This tree encodes certain dependencies between stems, e.g., the formal relation between the subjunctive and the preterite stem: if a verb has a distinct subjunctive stem, its vowel differs from the preterite stem vowel at least with respect to the feature [+front]. (21b) shows the tree for *werfen* ‘throw’, which also uses the [–1]-stem in the imperative ([+imp]).

(21) a. Generalized inheritance tree of strong verbs in German



b. Inheritance tree for {*werf*, *wirf*$_{-1}$, *warf*$_{+\text{pret}}$, *würfe*$_{+\text{subj}}$, *worfen*$_{+\text{part}}$}

[v[+front]rf]

[...[+high]...]$_{-1}$ | [...[-front]...]$_{+\text{pret}}$ | [...[-front,+round]...n]$_{+\text{part}}$

[…]$_{+\text{imp}}$ | [...[+front,+high,+round]...X]$_{+\text{subj}}$

As a consequence of AFFIX ORDER the person specification of the stem in (21b) implies that its lower-ranked number feature bears the default value ([–pl]). If a person-marked stem is used both in the singular and plural, it must also exhibit a number specification that enables its use in the plural. This can be seen in a subset of the strong verbs of the Low Franconian dialect of Cleves, which display vowel shortening in the 2nd person singular/plural and 3rd person singular; the latter has an additional vowel fronting feature.

(22) Stem allomorphy of Low Franconian *lopen* 'run' in the present tense

	SG	PL
1	*lo:p*	*lo:p-ə*
2	*l**o**p-t*	*l**o**p-t*
3	*l**œ**p-t*	*lo:p-ə*

Representation of stems
[lo:p]
[lop]$_{+2,\pm\text{pl}}$
[lœp]$_{-1}$

These trees make interesting predictions for language change: for instance, a change in the preterite stem should also affect the subjunctive, whereas the distinct subjunctive stem can be lost without affecting the preterite stem.

The stem allomorphy in Hungarian cross-cuts inflectional and derivational morphology and is, thus, reminiscent of Aronoff's (1994) "third stem" in Latin. However, unlike the data discussed by Aronoff, Hungarian stem allomorphy is prosodically determined, as shown in Stiebels & Wunderlich's analysis. These stems, which are dubbed "cracked stems," comprise several patterns (see (23)), reflecting outcomes of unproductive processes: vowel drop, metathesis, vowel shortening, v-stems and truncation. The affected segments are shown in bold face. The cracked stem, however, is not derived from the base stem by corresponding rules; it is listed as an independent lexical entry.

(23) Hungarian: second stems (Stiebels & Wunderlich 1999)

base stem		suffix I (DAT)	suffix II (CAUS-FIN)	cracked stem	suffix III (PL)
*bok**or***	'bush'	*bokor-nak*	*bokor-ért*	*bokr*$^{\mu}$	*bokr-ok*
*pe**hely***	'fluff'	*pehely-nek*	*pehely-ért*	*pelyh*$^{\mu}$	*pelyh-ek*
*mad**á**r*	'bird'	*madár-nak*	*madár-ért*	*madar*$^{\mu}$	*madar-ak*
*k**ő***	'stone'	*kő-nek*	*kő-ért*	*köv*$^{\mu}$	*köv-ek*
*borj**u***	'calf'	*borju-nak*	*borju-ért*	*borj*$^{\mu}$	*borj-ak*

The commonality of cracked stems lies in the presence of a floating mora (μ), which is associated with the vocalic root of certain types of suffixes. These suffixes (type III) alternate between an initial vowel and zero (e.g., plural -(*A*)*k*) and lack prosodic structure that is present in the other two types of affixes (consonant-initial suffixes such as the dative and vowel-initial suffixes such as the causal-final case marker). The distribution of stems results from an interaction of several faithfulness constraints (see Stiebels & Wunderlich for details).

6. Correspondence theory and MM

MM's assumption that affixation may overgenerate and that its output is filtered by certain selection principles has naturally led to implementations within OT/CT; see ??? (this volume) for a general introduction. CT-based implementations of MM have been used to account for stem allomorphy (Stiebels & Wunderlich 1999), clitic phenomena (Gerlach 1998, 2002, Ortmann & Popescu 2001, Popescu 2000, 2003), inventories of case and agreement markers (Stiebels 2000, 2002, Wunderlich 2003b), gaps and substitutions in paradigms (Wunderlich 2001a, b, 2003a), economy phenomena in agreement (Ortmann 2000, 2002a, 2002c), including a factorial typology of number marking (Ortmann 2004), and agent focus in Mayan (Stiebels 2006).

Certain features of MM also play a special role in CT-MM, namely underspecification and the asymmetrical status of positive and negative feature values. The latter is reflected in the use of faithfulness constraints. Since negative feature values are not expected to occur regularly in the output, faithfulness constraints are formulated with respect to positive feature values. Therefore, the introduction of positive features is penalized (DEP) as is the overriding of negative input features (IDENT). Likewise the missing correspondence of positive features in the output (MAX) constitutes a constraint violation; this lack of correspondence is not considered to be crucial in the case of negative input features. (24) summarizes the various settings for constraint violations.

(24) Input-output relations in CT-MM

	possible violations of			no violation	
	DEP	IDENT	MAX		
Input	[ ]	–F	+F	–F	+F
	↓	↓	↓	↓	↓
Output	+F	+F	[ ]	[ ]	+F

The workings of CT-MM may be illustrated with two exemplary cases: the factorial typology of linkers, i.e., case markers and pronominal affixes (agreement), and the approach to gaps and substitutions in paradigms.

6.1. *Factorial typology of linkers*

The factorial typology of linkers makes use of the features [±hr] and [±lr] introduced above. Depending on the relative ranking of the respective markedness (see (25a)) and faithfulness constraints (see (25b)), more or less elaborate inventories result. The faithfulness constraints require the visibility of the underlying abstract linking features. Thus, a violation of MAX(+lr) occurs, for instance, if an [+lr] argument is realized by NOM instead of ERG. In addition, some linker inventories emerge from a high ranking of UNIQUENESS, a constraint that bans the doubling of linkers in a given linking domain. In order to avoid confusion with the paradigm-related UNIQUENESS constraint, I will use the label L-UNIQUENESS.

(25) a. *[+hr], *[+lr] Avoid linkers that are specified as [+hr] or [+lr], respectively.
b. MAX(+hr), MAX(+lr) The abstract linking features [+hr], [+lr] have to be made visible by corresponding linkers.
c. L-UNIQUENESS: Each linker applies only once in a domain.

The input consists of the head's TS with the annotated specifications for the argument roles, while the output consists of the linker-annotated TS:

(26) a. Input λz[+hr,-lr] λy[+hr,+lr] λx[-hr,+lr])

b. Output_1 ACC DAT NOM
violates *[+hr] *[+hr],*[+lr] MAX(+lr)

c. Output_2 NOM ERG ERG
violates MAX(+hr) MAX(+hr),*[+lr] *[+lr]

Variable rankings of the constraints in (25) yield an adequate typology of attested linker inventories (see Stiebels 2000, 2002). The partial constraint rankings in (27) account for the respective linker inventories of (28).[2] A language that lacks morphological case or possesses only a single set of pronominal affixes exhibits the constraint ranking in (27h):

(27) a. {DAT, ACC, NOM}: [L-UNIQUENESS » *[+lr] » MAX(+lr)] & [MAX(+hr) » *[+hr]]
b. {DAT, ERG, NOM}: [L-UNIQUENESS » *[+hr] » MAX(+hr)] & [MAX(+lr) » *[+lr]]
c. {ACC, NOM}: [*[+lr] » [MAX(+lr), L-UNIQUENESS]] & [MAX(+hr) » *[+hr]]
d. {ERG_r, ACC, NOM}: [*[+hr,+lr] » MAX(+hr) » (*[+hr], MAX(+lr)) » *[+lr]] & [*[+hr,+lr] » L-UNIQUENESS]
e. {ERG_r, NOM}: [*[+hr] » L-UNIQUENESS » *[+lr] » MAX(+lr)] & [*[+hr] » MAX(+hr)]
f. {ERG, NOM}: [MAX(+lr) » *[+lr]] & [*[+hr] » [MAX(+hr), L-UNIQUENESS]]
g. {DAT, ERG, ACC, NOM}: [MAX(+lr) » *[+lr]] & [MAX(+hr) » *[+hr]]
h. {NOM}: [*[+hr] » [MAX(+hr), L-UNIQUENESS]] & [*[+lr] » [MAX(+lr), L-UNIQUENESS]]

(28) lists attested inventories of case markers and pronominal affixes (without any claim of completeness). ERG_r represents a restricted ergative, which is assigned only to the highest argument, although it would be compatible with further arguments (in languages that lack DAT). The fourth column shows the linking pattern of ditransitive verbs that emerges in the respective inventory (in the order dir.object–indir.object–subject).

(28) Attested inventories of case markers and pronominal affixes (agreement)

Inventory	Case	Agreement	ditransitive V
{DAT, ACC, NOM}	German	Choctaw	ACC-DAT-NOM
{DAT, ERG, NOM}	Basque	Basque	NOM-DAT-ERG
{ACC, NOM}	Quechua	Nahuatl	ACC-ACC-NOM
{ERG_r, ACC, NOM}	Wangkumara	?	ACC-ACC-ERG
{ERG_r, NOM}	Pitjantjatjara	Chinook	NOM-NOM-ERG
{ERG, NOM}	Kabardian	?	NOM-ERG-ERG
{DAT, ERG, ACC, NOM}	Thangu?	Yukulta	ACC-DAT-ERG

Many languages do not exhibit a uniform linking pattern across all categories. This is especially evident in ergative languages, whose agreement system quite often works on an accusative basis. These category-specific differences in the linker inventories have been highlighted by Silverstein (1976). Categories on the left of the hierarchy in (29) tend toward ACC systems, those on the right toward ERG systems.

2 The rankings in (27) each combine two independent subrankings. Languages may conflate these two subrankings into one ranking. An output has to be optimal in both subrankings.

(29) NP, DP scale
1/2 > 3/demonstratives > proper names > human > animate > inanimate

In CT-MM these category-specific linker inventories can be modeled with contextualized markedness constraints, which are derived by *Harmonic Alignment* (Prince & Smolensky 1993, Aissen 1999, 2003), yielding a natural hierarchy of markedness constraints. For example, depending on the relative ranking of MAX(+hr) with respect to the constraint ranking in (30), different inventories result (see Stiebels 2000, 2002 for details and Ortmann 2002c for another CT-MM analysis of such split types).

(30) *[+hr]/–animate » *[+hr]/+animate » *[+hr]/+human » *[+hr]/+def » *[+hr]/+SAP

6.2. *Analysis of gaps and substitutions*

CT-MM's approach to gaps and substitutions in affix combinations can be illustrated with Wunderlich's (2001a) account of such phenomena in the Papuan language Yimas. I will confine myself here to a few cases. The set of Yimas pronominal markers in the singular is shown in (31). Yimas lacks ACC forms of pronominal markers in the 3rd person singular.

(31) Yimas: pronominal affixes in the singular

	1SG	2SG	3SG
N	*ama-*	*ma-*	*na-*
E	*ka-*	*n-*	*n-*
A	*-ŋa*	*nan-*	*

(32) illustrates the corresponding affix combinations in transitive settings with both arguments in the singular:

(32) Yimas: transitive subject (x) – object (y) settings

x \ y	1	2	3
1		1E/2A *1E-2A *2A-1E	3N-1E
2	2N-1A *2E-1A		3N-2E
3	3N-1A *3E-1A	3N-2A *3E-2A	3N-3E

In (32) four settings do not show the expected patterns; all involve a speech act participant in object position. In the case of a 1st person subject – 2nd person singular object, a portmanteau form (1E/2SG.A, *kampan-*) is used instead of the concatenation of the 1E and 2SG.A markers. In the other cases, the E-linker is substituted by the N-linker. Apart from the constraints already discussed (L-UNIQ(UENESS), MAX(+hr), MAX(+lr)), Wunderlich further uses a faithfulness constraint that requires the general visibility of arguments (MAX(arg)), a linking constraint taken from LDG which requires the presence of the default linker (cf. (33a)), two language-specific linearization constraints (cf. (33b, c)), which may conflict with each other, and a morphological taboo constraint (cf. (33d)) that becomes relevant in ditransitive verbs. Such taboo constraints concerning the combination of certain person markers are not rare cross-linguistically (see also Lakämper & Wunderlich 1998, Heath 1998 and Bonet's 1991 *Person Case Constraint*).

(33) a. DEF(AULT): Every linking domain displays the default linker.
b. PERS(ON): The linear order of prefixes respects the hierarchy of person (3 < 2 < 1); the higher person attaches to the verb first ($[\ ]_{pers} \prec [+2] \prec [+1] \prec$ verb stem).
c. ROLE: The linear order of prefixes respects the hierarchy of roles (N < E < A); the higher role attaches to the verb first ($[\ ]_{role} \prec [+lr] \prec [+hr] \prec$ verb stem).
d. *2E+1A No affix combination expressing a 2nd person ergative and a 1st person accusative is allowed.

(34) shows the evaluation of a transitive setting with regular behavior. Since Yimas lacks an A-linker in the 3rd person, MAX(+hr) is violated in any case. Both PERS and ROLE converge here with respect to the admissible affix order.

(34) Evaluation of transparent transitive settings in Yimas
Input: λy[+hr,-lr,-1,-2] λx[-hr,+lr,+1,-2]

	L-UNIQ	IDENT(pers)	PERS	ROLE	MAX(+hr)	*2E+1A	DEF	MAX(+lr)	MAX(arg)
☞ 3N-1E					*				
1E-3N			*!	*	*				
3N-1N	*!				*			*	
1E					*		*!		*
1N					*			*!	*

The following constraint tableaux show the outcome of opaque affix combinations. '★' indicates the expected pattern on the basis of the linker inventory. (35) illustrates that affix combinations without the N-linker are not tolerated (due to a violation of default). The optimal candidate is one in which the E-linker is substituted by the N-linker. Substitution of the A-linker is not possible because of the linearization constraints and MAX(+hr). The same situation obtains with a 2nd person subject and 1st person object (here, the taboo constraint *2E+1A is violated in addition).

(35) Input: λy[+hr,-lr,+1,-2] λx[-hr,+lr,-1,-2]

	UNIQ	IDENT(pers)	PERS	ROLE	MAX(+hr)	*2E+1A	DEF	MAX(+lr)	MAX(arg)
☞ 3N-1A								*	
★ 3E-1A							*!		
1A-3E			*!	*			*		
1N-3E			*!		*				
3E-1N				*!	*				

(36) shows that the linearization constraints in the case of a 1st person subject and a 2nd person object lead to a conflict that could only be resolved by dropping of the 1E-linker, which would result in a gap. The portmanteau marker circumvents this problem. Since there is no such marker with 2nd person plural objects, the form with omission of the 1E-linker is optimal.

(36) Input: λy[+hr,-lr,-1,+2] λx[-hr,+lr,+1,-2]

	UNIQ	IDENT(pers)	PERS	ROLE	MAX(+hr)	*2E+1A	DEF	MAX(+lr)	MAX(arg)
1E					*!		*		*
2A							*	*!	*
★ 2A-1E				*!			*		
2N-1E					*!				
1N-2A			*!					*	
☞ 1E/2A							*		

The Yimas data provide further support for MM's use of underspecified entries of affixes because the substitution of markers in cases of conflict is easily accounted for.

7. Further reading

Further papers within the MM framework whose topics have not been mentioned in passing are Fabri's (1996) and Wunderlich's (1997, 2005) accounts of inverse morphology, Ortmann's (2000, 2002b) analysis of morphological licensing of modifiers, and Wunderlich's (in press) reanalysis of polarity phenomena.

A computational model of MM is presented in Fabri et al. (1996), showing its formalization and implementation in a declarative framework.

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