Theorien der Morphologie 4

Modul 006-1006: Grammatiktheorie, SoSe 2019

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Paradigm Economy

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Ref.: Carstairs (1987), Carstairs-McCarthy (1994), Müller (2007)

1. Introduction

Background:
(i) In Distributed Morphology, paradigms do not exist as genuine objects that, e.g., grammatical constraints can refer to. Rather, paradigms are epiphenomena – essentially, empirical generalizations that need to be derived in some way.
(ii) This view is incompatible with a more traditional view according to which paradigms exist as genuine entities in the grammar.

(1) *Some constraints on paradigms*:
   a. The Paradigm Economy Principle (Carstairs (1987))
   b. The No Blur Principle (Carstairs-McCarthy (1994))
   c. The Basic Instantiated Paradigm Principle (Williams (1994) vs. Bobaljik (2002))
   d. Optimal Paradigms (McCarthy (2003) vs. Bobaljik (2003) – we will discuss this later in the course)

Observation:
(i) Constraints like the Paradigm Economy Principle and No Blur restrict the number of possible inflection classes that can be generated on the basis of a given set of inflection markers (for a given grammatical category).
(ii) If such constraints cannot be adopted for principled reasons, there is a danger that the theory is not restrictive enough.
(iii) Principled reasons that preclude adopting constraints on the number of possible inflection classes (on the basis of a given marker inventory):

- non-existence of paradigms in morphological theory
- decomposition of inflection class features in order to account for *trans-paradigmatic syncretism*.

(Compare Noyer's (2005) Interclass Syncretism Constraint, which is similar in its effects to No Blur, and fundamentally incompatible with a decomposition of inflection class features.)

2. Excursus: Trans-Paradigmatic Syncretism and Decomposition of Inflection Class Features

Note:
Intra-paradigmatic syncretism can be accounted for by decomposing privative case featues into more primitive, binary case features that are cross-classified (yielding natural classes of cases). These primitive features are semantics-based in Jakobson (1962a), Jakobson (1962b),

T_1: Syncretism within and across inflection classes in Russian

	I_m	$II_{f,m}$	III_f	IV_n
nom	Ø	a	Ø	o
acc	Ø/a	u	Ø	o
dat	u	e	i	u
gen	a	i	i	a
inst	om	oj	ju	om
loc	e	e	i	e

Neidle (1988), Franks (1995)), and syntax-based in Bierwisch (1967), Wiese (1999), Müller (2002); we adopt the latter view.

(2) *Decomposition of cases in Russian*: [±subject], [±governed], [±oblique]

nominative:	[+subj,–gov,–obl]
accusative:	[–subj,+gov,–obl]
dative:	[–subj,+gov,+obl]
genitive:	[+subj,+gov,+obl]
instrumental:	[+subj,–gov,+obl]
locative:	[–subj,–gov,+obl]

Note:
Trans-paradigmatic syncretism can be accounted in the same way by decomposing privative class features into more primitive, binary class features that are cross-classified (yielding natural classes of inflection classes); see Halle (1992) on Latvian noun inflection ([±marginal], [±marked] in addition to the "standard" class features A, B); Nesset (1994) on Russian noun inflection ([±nom-end] and [a/igen-end]); Oltra Massuet (1999) on verbal inflection in Catalan; Stump (2001) on verbal inflection in Bulgarian; Müller (2005) on Icelandic noun inflection; Trommer (2005) on Amharic verbs. Also see Börjesson (2006) (Slovene noun declension), Opitz (2006) (Albanian noun declension), and Weisser (2006) (Croatian noun declension).

(3) *Decomposition of inflection classes in Russian*: [±α], [±γ]

I:	[+α,–γ]	*zavod*$_m$ ('factory')
II:	[–α,+γ]	*komnat*$_f$ ('room'), *mužčin-*$_m$ ('man')
III:	[–α,–γ]	*tetrad'*$_f$ ('notebook')
IV:	[+α,+γ]	*mest*$_n$ ('place')

(4) *Inflection markers (singular)*:

a.	/oj/:	{[+N],[–α,+γ],[+subj,–gov,+obl]}
b.	/ju/:	{[+N],[–α,–γ],[+subj,–gov,+obl]}
c.	/om/:	{[+N],[+α],[+subj,–gov,+obl]}
d.	/e/:	{[+N],[–α,+γ],[–subj,+gov,+obl]}
e.	/e/:	{[+N],[¬(–α,–γ)],[–gov,+obl]}
f.	/o/:	{[+N],[+α,+γ],[–obl]}
g.	/Ø/:	{[+N],[–γ],[–obl]}
h.	/i/:	{[+N],[–α],[+obl]}
i.	/u/:	{[+N],[–subj,+gov]}

j. /a/: {[+N]}

Note:
Underspecified class information is underlined in inflection marker specifications.

→ End of excursus. Back to paradigm economy.

Two possible strategies:
(i) argue that the question of how inflection classes can be constrained is irrelevant from a synchronic perspective;
(ii) argue that restrictions on the number of possible inflection classes (based on a given marker inventory) follow from independently motivated assumptions, without invoking specific constraints that explicitly impose restrictions on possible inflection classes.
I adopt the latter strategy.

A *meta-principle* that restricts possible inflectional systems (null hypothesis for both child and linguist) (Alexiadou & Müller (2008)):

(5) *Syncretism Principle*:
Identity of form implies identity of function
(within a certain domain, and unless there is evidence to the contrary).

Claim:
Accompanied by two simple and widely accepted auxiliary assumptions (which I call *Elsewhere* and *Blocking*), the Syncretism Principle significantly restricts the number of possible inflection classes by itself:

(6) *Inflection Class Economy Theorem*:
Given a set of n inflection markers, there can be at most 2^{n-1} inflection classes, independently of the number of grammatical categories that the markers have to distribute over.

3. Paradigm Economy

3.1. The Paradigm Economy Principle

Background question:
What is the largest number of inflection classes (paradigms) which a given array of inflectional resources can be organized into?

(7) *The Paradigm Economy Principle* (Carstairs (1987, 51)):
When in a given language L more than one inflectional realization is available for some bundle or bundles of non-lexically-determined morphosyntactic properties associated with some part of speech N, the number of macroparadigms for N is no greater than the number of distinct "rival" macroinflections available for that bundle which is most genereously endowed with such rival realizations.

Consequence:
The number of (macro-) inflection classes does not exceed the greatest number of allomorphs.

(8) *An impossible paradigm* (Carstairs-McCarthy (1998)):

	Class A	Class B	Class C	Class D
Cell 1	a	a	f	f
Cell 2	b	e	e	e
Cell 3	c	c	h	h
Cell 4	d	d	d	g

- number of inflection classes: 4
- greatest number of allomorphic variation: 2

(9) *Hungarian present indefinite verb inflection*

	Indicative	Subjunctive
Sg 1	ok, ek, ök, om, em, öm	ak, ek am em
2	(a)sz, (e)sz, ol, el, öl	Ø, ál, él
3	Ø, ik	on, en, ön, ék
Pl 1	unk, ünk	unk, ünk
2	(o)tok, (e)tek, (ö)tök	atok, etek
3	(a)nak, (e)nek	anak, enek

Logical possibility:
Given complete independence of distribution of markers over (macro-) inflection classes: *276.480* inflection classes.

Actual (macro-) inflection classes:
very few. How many exactly?

(10) *Some Hungarian verbs*

Indicative					
	olvasni 'read'	ülni 'sit'	enni 'eat'	érteni 'understand'	írni 'write'
Sg 1	olvas-ok	ül-ök	esz-em	ért-ek	ír-ok
2	olvas-ol	ül-sz	esz-el	ért-esz	ír-sz
3	olvas-Ø	ül-Ø	esz-ik	ért-Ø	ír-Ø
Pl 1	olvas-unk	ül-ünk	esz-unk	ért-ünk	ír-unk
2	olvas-tok	ül-tök	esz-tek	ért-etek	ír-tok
3	olvas-nak	ül-nek	esz-nek	ért-enek	ír-nak
Subjunctive					
Sg 1	olvas-ak	ülj-ek	egy-em	értj-ek	irj-ak
2	olvas-Ø/-ál	ülj-Ø/-él	egy-él	értj-Ø/-él	írj-Ø/-ál
3	olvas-on	ülj-en	egy-ek	értj-en	írj-on
Pl 1	olvas-unk	ülj-ünk	egy-ünk	értj-ünk	írj-unk
2	olvas-atok	ülj-etek	egy-etek	értj-etek	írj-atok
3	olvas-anak	ülj-enek	egy-enek	értj-enek	írj-anak

Conclusion:
Abstracting away from differences that are (morpho-) phonologically predictable, there are

only two (macro-) inflection classes: the *normal* conjugation and the *ik* conjugation (each with a back-vowel and a front-vowel version).

(11) *Hungarian present indefinite conjugations: analysis*

	Indicative		Subjunctive	
	normal	ik	normal	ik
Sg 1	ok	om	ak	am
2	ol (after sibilants) asz (elsewhere)	ol	Ø/ál	Ø/ál
3	Ø	ik	on	ék
Pl 1	unk	unk	unk	unk
2	(o)tok	(o)tok	(o)tok	(o)tok
3	(a)nak	(a)nak	(a)nak	(a)nak

Observation:
The Paradigm Economy Principle crucially relies on the notion of macro-paradigm (or macro-inflection class).

(12) *Macro-Paradigm*:
A macro-paradigm consists of:

a. any two or more similar paradigms whose inflectional differences either can be accounted for phonologically, or else correlate consistently with differences in semantic or lexically determined syntactic properties (like gender);
or
b. any paradigm which cannot be thus combined with other paradigm(s).

(13) *German noun inflection*

	I: masc, neut $Hund_m$ ('dog'), $Schaf_n$ ('sheep')	II: masc $Baum_m$ ('tree') $FloSS_n$ ('raft')	III: neut, masc $Buch_n$ ('book'), $Mann_m$ ('man')	IV: masc, neut $Strahl_m$ ('ray') $Auge_n$ ('eye')
nom/sg	Ø	Ø	Ø	Ø
acc/sg	Ø	Ø	Ø	Ø
dat/sg	Ø	Ø	Ø	Ø
gen/sg	(e)s	(e)s	(e)s	(e)s
nom/pl	(e)	"(e)	"er	(e)n
acc/pl	(e)	"(e)	"er	(e)n
dat/pl	(e)n	"(e)n	"ern	(e)n
gen/pl	(e)	"(e)	"er	(e)n

	V: masc ('weak') $Planet_m$ ('planet')	VI: fem $Ziege_f$ ('goat')	VII: fem $Maus_f$ ('mouse')	VIII: fem $Drangsal_f$ ('distress')
nom/sg	Ø	Ø	Ø	Ø
acc/sg	(e)n	Ø	Ø	Ø
dat/sg	(e)n	Ø	Ø	Ø
gen/sg	(e)n	Ø	Ø	Ø
nom/pl	(e)n	(e)n	"(e)	(e)
acc/pl	(e)n	(e)n	"(e)	(e)
dat/pl	(e)n	(e)n	"(e)n	(e)n
gen/pl	(e)n	(e)n	"(e)	(e)

German noun inflection and paradigm economy:
The classification in (13) is that of Alexiadou & Müller (2008), but there is a similar taxonomy of inflection classes in Carstairs (1986, 8). (Carstairs actually has 14 inflection classes, including ones with *s* as a plural marker.)

Observation:
The greatest number of allomorphic variation is 4 (nom/acc/gen plural; 5 if /s/ is included).

Conclusion:
There can at most be 4 (5) macro-inflection classes.

(14) *Macro-inflection classes for German noun declension*

a. III (*"er*-plural)
b. V (so-called 'weak masculines')
c. IV/VI (*en*-plural; gen/sg *s* for masc/neut; gen/sg Ø for fem)
d. II/VII (*"e*-plural; gen/sg *s* for masc/neut; gen/sg Ø for fem)
e. I/VIII (*e*-plural; gen/sg *s* for masc/neut; gen/sg Ø for fem)

Problem:
It seems that (14-de) must be combined into a single macroclass, with Umlaut accounted for independently (viz., (morpho-) phonologically). Carstairs (1987, 58): Stem allomorphy does indeed not give rise to different macro-inflection classes (there is "a distinction between affixal and non-affixal inflection").

(15) *Russian noun inflection*

a. Singular

	Ia/Ib$_m$	IIa/IIb$_{f,m}$	IIIa/IIIb$_f$	IVa/IVb$_n$
nom/sg	Ø	a	Ø	o
acc/sg	*Ø/a*	u	Ø	o
dat/sg	u	e	i	u
gen/sg	a	i	i	a
inst/sg	om	oj	ju	om
loc/sg	e	e	i	e

b. Plural

	Ia/Ib$_m$	IIa/IIb$_{f,m}$	IIIa/IIIb$_f$	IVa/IVb$_n$
nom/pl	y	y	i	a
acc/pl	*y/ov*	*y/Ø*	*i/ej*	*a/Ø*
dat/pl	am	am	jam	am
gen/pl	ov	Ø	ej	Ø
inst/pl	ami	ami	jami	ami
loc/pl	ax	ax	jax	ax

Problem:

1. If the [acc ← gen] animacy effect with class I noun stems and all plural noun stems gives rise to different inflection classes in each case, the number of inflection classes would have to be *8*.
2. However, the greatest number of allomorphic variation is *4* (accusative singular).

Solution:

- The variation in acc/sg (class 1) and acc/pl (all classes) contexts correlates consistently with differences in semantic properties (*animacy*), and is thus predictable: 8 → 4.
- The differences between class 1 and class 4 are also predictable on the basis of *gender*: 4 → 3.
- Thus, there are only three macro-inflection classes in Russian noun declension.

Conclusion:
Given the concept of macro-paradigm (or macro-inflection class), counter-examples to the Paradigm Economy Principle can be explained away. On this view, if a different inflectional pattern can be described by invoking gender features, semantic features (like animacy), phonological features, or if it involves non-affixal inflection, it is irrelevant for paradigm economy: Only those differences count which are absolutely irreducible.

Problem:
(i) Without a concept like that of a macro-paradigm, the Paradigm Economy Principle would be much too restrictive; it would exclude many of the attested inflection patterns in languages with inflection classes.
(ii) However, assuming such a liberal notion of macro-paradigm reduces the Paradigm Economy Principle's predictive power.

3.2. No Blur

Background:
The No Blur Principle is proposed in Carstairs-McCarthy (1994) as a successor to his earlier Paradigm Economy Principle.

(16) *The No Blur Principle* (Carstairs-McCarthy (1994, 742)):
Within any set of competing inflectional realizations for the same paradigmatic cell, no more than one can fail to identify inflection class unambiguously.

Underlying idea:
There is typically one *elsewhere marker* that is not specified for inflection class, but no more than that.

Note:
Just like the Paradigm Economy Principle, the No Blur Principle blocks (what looks like) a constant *re-use* of inflectional material in various inflection classes, and thereby restricts the number of possible inflection classes over a given inventory of markers. (Comment: However, this is exactly what seems to happen in inflectional systems of various types, again and again. Moreover, No Blur, at least as a tendency, is in conflict with the existence of *trans-paradigmatic syncretism*).

(17) *Strong feminine inflection classes in Icelandic*

	Fa *vél* ('machine')	Fa′ *drottning* ('queen')	Fi *mynd* ('picture')	Fc1 *geit* ('goat')	Fc2 *vík* ('bay')
nom sg	vél-Ø	drottning-Ø	mynd-Ø	geit-Ø	vík-Ø
acc sg	vél-Ø	drottning-u	mynd-Ø	geit-Ø	vík-Ø
dat sg	vél-Ø	drottning-u	mynd-Ø	geit-Ø	vík-Ø
gen sg	vél-ar	drottning-ar	mynd-ar	geit-ar	vík-ur
nom pl	vél-ar	drottning-ar	mynd-ir	geit-ur	vík-ur
acc pl	vél-ar	drottning-ar	mynd-ir	geit-ur	vík-ur
dat pl	vél-um	drottning-um	mynd-um	geit-um	vík-um
gen pl	vél-a	drottning-a	mynd-a	geit-a	vík-a

Analysis (Carstairs-McCarthy (1994, 740-742)):

- Genitive singular and nominative plural are the *leading forms* ('Kennformen'; cf. Wurzel (1987)).
- Markers for gen/sg: *ur* ↔ gen/sg, class Fc2; *ar* ↔ gen/sg.
- Markers for nom/pl: *ar* ↔ nom/pl, class Fa; *ir* ↔ nom/pl, class Fi; *ur* ↔ nom/pl

Problem:
The No Blur Principle makes wrong predictions if the complete system of Icelandic noun declension is taken in to account: In both gen/sg and nom/pl contexts, there is more than one marker that fails to unambiguously identify inflection class.

(18) *The complete system of inflection classes in Icelandic noun inflection* (Kress (1982), Müller (2005)):

	1 Ma	2 Na	3 Fa(′)	4 Mi	5 Fi	6 Mu	7 Mc	8 Fc1	9 Fc2	10 Mw	11 Nw	12 Fw
nom sg	ur	Ø	Ø	ur	Ø	ur	ur	Ø	Ø	i	a	a
acc sg	Ø	Ø	Ø (u)	Ø	Ø	Ø	Ø	Ø	Ø	a	a	u
dat sg	i	i	Ø (u)	Ø	Ø	i	i	Ø	Ø	a	a	u
gen sg	s	s	ar	ar	ar	ar	ar	ar	ur	a	a	u
nom pl	ar	Ø	ar	ir	ir	ir	ur	ur	ur	ar	u	ur
acc pl	a	Ø	ar	i	ir	i	ur	ur	ur	a	u	ur
dat pl	um	um	um	um	um	um	um	um	um	um	um	um
gen pl	a	a	a	a	a	a	a	a	a	a	(n)a	(n)a

Solution:

- No Blur holds only for a set of inflection classes of the same *gender*.
- However, this still does not seem to suffice: In masculine nom/pl contexts, neither *ar* (Ma, Mw) nor *ir* (Mi, Mu) unambiguously identifies inflection class.

Trans-paradigmatic syncretism and No Blur:
This problem is indicative of a more general potential problem that is raised by the No Blur Principle (as well as by Noyer's (2005) related Interclass Syncretism Constraint): Trans-paradigmatic syncretism is a recurring pattern of inflectional systems. This pattern has successfully been addressed by standard techniques (Jakobson (1936), Bierwisch (1967)) involving feature decomposition and underspecification (which permits a reference by inflection marker specifications to natural classes of inflection classes). See Halle (1992), Oltra Massuet (1999), Wiese (1999), Stump (2001), Alexiadou & Müller (2008), Müller (2005), Trommer (2005), Börjesson (2006), Opitz (2006), Weisser (2006). In all these approaches, more than one of the inflection markers competing for a given instantiation of a grammatical category fails to unambiguously identify inflection class, in violation of the No Blur Principle.

Conclusion:
(i) Paradigm Economy Principle and No Blur Principle (Noyer's Interclass Syncretism Constraint) reduce the set of logically possible inflection classes (based on a given inventory of markers) to a very small set.
(ii) However, these constraints constantly face the danger of being *too* restrictive.
(iii) Furthermore, these constraints are incompatible with the view that paradigms are mere epiphenomena, and with the view that trans-paradigmatic syncretism can be accounted for by invoking class feature decomposition and underspecification.
(iv) This warrants looking for alternative ways of bringing about paradigm economy.

4. Claim

(19) *Inflection Class Economy Theorem*:
Given a set of n inflection markers, there can be at most 2^{n-1} inflection classes, independently of the number of instantiations of the grammatical category that the markers have to distribute over.

Note:
The number of 2^{n-1} inflection classes encodes the powerset of the inventory of markers, minus one radically underspecified marker. For instance: Assuming an abstract system with five markers and six instantiations of a grammatical category (e.g., case), the Inflection Class Economy Theorem states that there can at most be sixteen (i.e., $2^{5-1} = 2^4$) inflection classes, out of the 15.625 (i.e., 5^6) that would otherwise be possible.

Claim:
The Inflection Class Economy Theorem follows under any morphological theory that makes the three assumptions in (20), (21), and (22), which I call 'Syncretism', 'Elsewhere', and 'Blocking'.
(I basically presuppose an approach along the lines of Distributed Morphology (Halle & Marantz (1993; 1994), Noyer (1992)), but things are exactly the same under alternative morphological theories, e.g., Minimalist Morphology (Wunderlich (1996; 1997)), or Paradigm Function Morphology (Stump (2001)).)

(20) *Syncretism* (first assumption):
The Syncretism Principle holds: For each marker, there is a unique specification of morpho-syntactic features.

Note:
The Syncretism Principle underlies much recent (and, based on the Jakobsonian tradition, some not so recent) work in inflectional morphology; it provides simple and elegant analyses, and it has been empirically confirmed for a variety of inflectional systems in the world's languages.

(21) *Elsewhere* (second assumption):
There is always one elsewhere marker that is radically underspecified with respect to inflection class (and more generally). Other markers may be underspecified to an arbitrary degree (including not at all).

Note:
(i) Underspecification as a means to account for syncretism is employed in most recent theories of inflectional morphology, including Distributed Morphology, Minimalist Morphology, and Paradigm Function Morphology.
(ii) The assumption that there is always one radically underspecified elsewhere marker in inflectional systems is quite common (see, e.g., Stump's (2001) Identity Function Default rule).
(ii-a) It is well-motivated empirically because it can account for 'discontinuous' occurrences of markers in paradigms (where natural classes captured by non-radical underspecification is unlikely to be involved).
(ii-b) It ensures that there are (usually) no paradigmatic gaps in inflectional systems (which should otherwise be an option, given underspecification).

(22) *Blocking* (third assumption):
Competition of underspecified markers is resolved by choosing the most specific marker: For all (competing) markers α, β, either α is more specific than β, or β is more specific than α.

Note:
A Specificity constraint along these lines is adopted in Distributed Morphology (typically as part of the definition of the Subset Principle, see Halle (1997)), in Minimalist Morphology (see Wunderlich (1996; 1997; 2004)), and in Paradigm Function Morphology (Stump (2001) calls the relevant constraint Panini's Principle).

Consequence:
(i) Syncretism is systematic in the sense that ideally, only one specification of morpho-syntactic features is associated with any given inflection marker.
(ii) For any given fully specified context, there is always one inflection marker that fits.
(iii) For any given fully specified context, there is never more than one inflection marker that

fits.
(Elsewhere and Blocking emerge as two sides of the same coin; see 'Completeness' and 'Uniqueness' in Wunderlich (1996, 99).)

Two remaining issues:
(i) How does the Inflection Class Economy Theorem constrain inflectional systems?
(ii) How does the Inflection Class Economy Theorem follow as a theorem from Syncretism, Elsewhere, and Blocking?

5. Illustration

(23) *Two versions of the basic question*:

a. Given an inventory of markers for a certain domain (e.g., noun inflection), how many inflection classes can there be?
b. Given an inventory of markers *with associated features encoding a grammatical category (e.g., case)* for a certain domain (e.g., noun inflection), how many inflection classes can there be?

Assumption:
(23-a) is the more interesting question: It does not presuppose that the specification of a marker for a grammatical category (e.g., with respect to case and/or number) is somehow privileged, i.e., more basic than its inflection class features. (Carstairs (1987) only tries to answer (23-b).)

A system without restrictions:
If, in a given domain (e.g., noun inflection), there are n markers for m instantiations of a grammatical category (e.g., case), the markers can be grouped into n^m distinct inflection classes (i.e., the set of m-tuples over an input set with n members). [Thanks to the comp4ling toolbox, UMass linguistics.]

Abstract example 1: 3 markers, 4 cases: 81 ($= 3^4$) possible inflection classes

a a a a	a b c a	b a b a	b c a a	c a c a	c c b a
a a a b	a b c b	b a b b	b c a b	c a c b	c c b b
a a a c	a b c c	b a b c	b c a c	c a c c	c c b c
a a b a	a c a a	b a c a	b c b a	c b a a	c c c a
a a b b	a c a b	b a c b	b c b b	c b a b	c c c b
a a b c	a c a c	b a c c	b c b c	c b a c	c c c c
a a c a	a c b a	b b a a	b c c a	c b b a	
a a c b	a c b b	b b a b	b c c b	c b b b	
a a c c	a c b c	b b a c	b c c c	c b b c	
a b a a	a c c a	b b b a	c a a a	c b c a	
a b a b	a c c b	b b b b	c a a b	c b c b	
a b a c	a c c c	b b b c	c a a c	c b c c	
a b b a	b a a a	b b c a	c a b a	c c a a	
a b b b	b a a b	b b c b	c a b b	c c a b	
a b b c	b a a c	b b c c	c a b c	c c a c	

Note:
(i) The letters *a*, *b*, and *c* stand for the three markers.

(ii) All four-letter rows (4-tuples separated by either a vertical line or a line break) correspond to one inflection class, with the first marker in a row being used for the first instantiation of case (e.g., nominative), the second one for the second instantiation of case (e.g., accusative), the third one for the third instantiation of case (e.g., dative), and the fourth one for the fourth instantiation of case (e.g., genitive).
(iii) It is unlikely that a language can be found in which eighty-one inflection classes have been generated on the basis of three markers and four instantiations of a grammatical category.

(24) *Predictions for example 1*

a. Paradigm Economy Principle, worst case scenario:
3 inflection classes: the size of the inventory
b. No Blur Principle, worst case scenario:
9 inflection classes: ((3-1)×4)+1
c. Inflection Class Economy Theorem, worst case scenario:
4 inflection classes: 2^{3-1}

(25) *Explanation of worst case scenarios, Paradigm Economy Principle*:
All three markers can be allomorphs for a single case specification (e.g., *a*, *b*, and *c* can all be accusative markers); still, there can then only be three distinct inflection classes.

(26) *Explanation of worst case scenarios, No Blur Principle*:

a. There is one default marker (say, *a*).
b. One class consists only of default markers (*aaaa*).
c. All the other inflection classes differ from this class by replacing one of the *a*'s with either *b* or *c* (*baaa*, *abaa*, *aaba*, *aaab*, *caaa*, *acaa*, *aaca*, *aaac*), so that all classes respect the No Blur Principle.
d. Adding another class with more than one *b*, or more than one *c*, or a – perhaps minimal – combination of *b*'s and *c*'s (cf. *bbaa*, or *aacc*, or *abca*, etc.) will invariably lead to a violation of the No Blur Principle because either *b* or *c* (or both) will cease to be inflection-class specific.
e. In general, the No Blur Principle predicts that there can at most be ((n-1)×m)+1 inflection classes, for n markers and m instantiations of a grammatical category: Every marker except for one – the default marker, hence "–1" – can appear for a given instantiation of a grammatical category only in one inflection class; and "+1" captures a class consisting exclusively of default markers.

Note:
Assuming default markers that are specific with respect to instantiations of a grammatical category (such that, e.g., *a* is the default marker for the first instantiation, *b* for the second, *c* for the third, and perhaps again *a* for the fourth) instead of an extremely general default marker *a*, does not change things: This would be compatible with No Blur, but it could not increase the number of possible inflection classes. In the case at hand, the maximal set of inflection classes would include *abca*, *bbca*, *cbca*, *aaca*, *acca*, *abaa*, *abba*, *abcb*, *abcc*.

(27) *Predictions for example 2*

a. Paradigm Economy Principle, worst case scenario:
5 inflection classes: the size of the inventory
b. No Blur Principle, worst case scenario:

Abstract example 2: 5 markers, 3 cases: 125 ($= 5^3$) possible inflection classes

a a a	a d a	b b a	b e a	c c a	d a a	d d a	e b a	e e a	
a a b	a d b	b b b	b e b	c c b	d a b	d d b	e b b	e e b	
a a c	a d c	b b c	b e c	c c c	d a c	d d c	e b c	e e c	
a a d	a d d	b b d	b e d	c c d	d a d	d d d	e b d	e e d	
a a e	a d e	b b e	b e e	c c e	d a e	d d e	e b e	e e e	
a b a	a e a	b c a	c a a	c d a	d b a	d e a	e c a		
a b b	a e b	b c b	c a b	c d b	d b b	d e b	e c b		
a b c	a e c	b c c	c a c	c d c	d b c	d e c	e c c		
a b d	a e d	b c d	c a d	c d d	d b d	d e d	e c d		
a b e	a e e	b c e	c a e	c d e	d b e	d e e	e c e		
a c a	b a a	b d a	c b a	c e a	d c a	e a a	e d a		
a c b	b a b	b d b	c b b	c e b	d c b	e a b	e d b		
a c c	b a c	b d c	c b c	c e c	d c c	e a c	e d c		
a c d	b a d	b d d	c b d	c e d	d c d	e a d	e d d		
a c e	b a e	b d e	c b e	c e e	d c e	e a e	e d e		

13 inflection classes: ((5-1)×3)+1
(E.g., assuming *a* as a default marker, *aaa*, *baa*, *aba*, *aab*, *caa*, *aca*, *aac*, *daa*, *ada*, *aad*, *eaa*, *aea*, *aae*)

c. Inflection Class Economy Theorem, worst case scenario:
16 inflection classes: 2^{5-1}

(28) *Predictions for example 3*

a. Paradigm Economy Principle, worst case scenario:
5 inflection classes: the size of the inventory

b. No Blur Principle, worst case scenario:
17 inflection classes: ((5-1)×4)+1
(E.g., *aaaa*, *baaa*, *abaa*, *aaba*, *aaab*, *caaa*, *acaa*, *aaca*, *aaac*, *daaa*, *adaa*, *aada*, *aaad*, *eaaa*, *aeaa*, *aaea*, *aaae*.)

c. Inflection Class Economy Theorem, worst case scenario:
16 inflection classes: 2^{5-1}

Conclusion so far:
The Inflection Class Economy Theorem restricts possible inflection classes in a way that is roughly comparable to the Paradigm Economy and No Blur Principles.

6. Deriving the Inflection Class Economy Theorem

Recall:
(i) Syncretism: Only one morpho-syntactic feature specification is associated with each marker of the inventory for a given morphological domain (exceptions apart).
(ii) Elsewhere: There is always one marker that in principle fits into every context of fully specified morpho-syntactic features.
(iii) Blocking: There is always only one marker that can in fact be used for any fully specified context of morpho-syntactic features.

(29) *Argument via marker deactivation combinations*:

Abstract example 3: 5 markers, 4 cases: 625 ($= 5^4$) possible inflection classes

a a a a	a c c a	a e e a	b c b a	b e d a	c c a a	c e c a	d b e a	d e b a	e b d a	e e a a					
a a a b	a c c b	a e e b	b c b b	b e d b	c c a b	c e c b	d b e b	d e b b	e b d b	e e a b					
a a a c	a c c c	a e e c	b c b c	b e d c	c c a c	c e c c	d b e c	d e b c	e b d c	e e a c					
a a a d	a c c d	a e e d	b c b d	b e d d	c c a d	c e c d	d b e d	d e b d	e b d d	e e a d					
a a a e	a c c e	a e e e	b c b e	b e d e	c c a e	c e c e	d b e e	d e b e	e b d e	e e a e					
a a b a	a c d a	b a a a	b c c a	b e e a	c c b a	c e d a	d c a a	d e c a	e b e a	e e b a					
a a b b	a c d b	b a a b	b c c b	b e e b	c c b b	c e d b	d c a b	d e c b	e b e b	e e b b					
a a b c	a c d c	b a a c	b c c c	b e e c	c c b c	c e d c	d c a c	d e c c	e b e c	e e b c					
a a b d	a c d d	b a a d	b c c d	b e e d	c c b d	c e d d	d c a d	d e c d	e b e d	e e b d					
a a b e	a c d e	b a a e	b c c e	b e e e	c c b e	c e d e	d c a e	d e c e	e b e e	e e b e					
a a c a	a c e a	b a b a	b c d a	c a a a	c c c a	c e e a	d c b a	d e d a	e c a a	e e c a					
a a c b	a c e b	b a b b	b c d b	c a a b	c c c b	c e e b	d c b b	d e d b	e c a b	e e c b					
a a c c	a c e c	b a b c	b c d c	c a a c	c c c c	c e e c	d c b c	d e d c	e c a c	e e c c					
a a c d	a c e d	b a b d	b c d d	c a a d	c c c d	c e e d	d c b d	d e d d	e c a d	e e c d					
a a c e	a c e e	b a b e	b c d e	c a a e	c c c e	c e e e	d c b e	d e d e	e c a e	e e c e					
a a d a	a d a a	b a c a	b c e a	c a b a	c c d a	d a a a	d c c a	d e e a	e c b a	e e d a					
a a d b	a d a b	b a c b	b c e b	c a b b	c c d b	d a a b	d c c b	d e e b	e c b b	e e d b					
a a d c	a d a c	b a c c	b c e c	c a b c	c c d c	d a a c	d c c c	d e e c	e c b c	e e d c					
a a d d	a d a d	b a c d	b c e d	c a b d	c c d d	d a a d	d c c d	d e e d	e c b d	e e d d					
a a d e	a d a e	b a c e	b c e e	c a b e	c c d e	d a a e	d c c e	d e e e	e c b e	e e d e					
a a e a	a d b a	b a d a	b d a a	c a c a	c c e a	d a b a	d c d a	e a a a	e c c a	e e e a					
a a e b	a d b b	b a d b	b d a b	c a c b	c c e b	d a b b	d c d b	e a a b	e c c b	e e e b					
a a e c	a d b c	b a d c	b d a c	c a c c	c c e c	d a b c	d c d c	e a a c	e c c c	e e e c					
a a e d	a d b d	b a d d	b d a d	c a c d	c c e d	d a b d	d c d d	e a a d	e c c d	e e e d					
a a e e	a d b e	b a d e	b d a e	c a c e	c c e e	d a b e	d c d e	e a a e	e c c e	e e e e					
a b a a	a d c a	b a e a	b d b a	c a d a	c d a a	d a c a	d c e a	e a b a	e c d a						
a b a b	a d c b	b a e b	b d b b	c a d b	c d a b	d a c b	d c e b	e a b b	e c d b						
a b a c	a d c c	b a e c	b d b c	c a d c	c d a c	d a c c	d c e c	e a b c	e c d c						
a b a d	a d c d	b a e d	b d b d	c a d d	c d a d	d a c d	d c e d	e a b d	e c d d						
a b a e	a d c e	b a e e	b d b e	c a d e	c d a e	d a c e	d c e e	e a b e	e c d e						
a b b a	a d d a	b b a a	b d c a	c a e a	c d b a	d a d a	d d a a	e a c a	e c e a						
a b b b	a d d b	b b a b	b d c b	c a e b	c d b b	d a d b	d d a b	e a c b	e c e b						
a b b c	a d d c	b b a c	b d c c	c a e c	c d b c	d a d c	d d a c	e a c c	e c e c						
a b b d	a d d d	b b a d	b d c d	c a e d	c d b d	d a d d	d d a d	e a c d	e c e d						
a b b e	a d d e	b b a e	b d c e	c a e e	c d b e	d a d e	d d a e	e a c e	e c e e						
a b c a	a d e a	b b b a	b d d a	c b a a	c d c a	d a e a	d d b a	e a d a	e d a a						
a b c b	a d e b	b b b b	b d d b	c b a b	c d c b	d a e b	d d b b	e a d b	e d a b						
a b c c	a d e c	b b b c	b d d c	c b a c	c d c c	d a e c	d d b c	e a d c	e d a c						
a b c d	a d e d	b b b d	b d d d	c b a d	c d c d	d a e d	d d b d	e a d d	e d a d						
a b c e	a d e e	b b b e	b d d e	c b a e	c d c e	d a e e	d d b e	e a d e	e d a e						
a b d a	a e a a	b b c a	b d e a	c b b a	c d d a	d b a a	d d c a	e a e a	e d b a						
a b d b	a e a b	b b c b	b d e b	c b b b	c d d b	d b a b	d d c b	e a e b	e d b b						
a b d c	a e a c	b b c c	b d e c	c b b c	c d d c	d b a c	d d c c	e a e c	e d b c						
a b d d	a e a d	b b c d	b d e d	c b b d	c d d d	d b a d	d d c d	e a e d	e d b d						
a b d e	a e a e	b b c e	b d e e	c b b e	c d d e	d b a e	d d c e	e a e e	e d b e						
a b e a	a e b a	b b d a	b e a a	c b c a	c d e a	d b b a	d d d a	e b a a	e d c a						
a b e b	a e b b	b b d b	b e a b	c b c b	c d e b	d b b b	d d d b	e b a b	e d c b						
a b e c	a e b c	b b d c	b e a c	c b c c	c d e c	d b b c	d d d c	e b a c	e d c c						
a b e d	a e b d	b b d d	b e a d	c b c d	c d e d	d b b d	d d d d	e b a d	e d c d						
a b e e	a e b e	b b d e	b e a e	c b c e	c d e e	d b b e	d d d e	e b a e	e d c e						
a c a a	a e c a	b b e a	b e b a	c b d a	c e a a	d b c a	d d e a	e b b a	e d d a						
a c a b	a e c b	b b e b	b e b b	c b d b	c e a b	d b c b	d d e b	e b b b	e d d b						
a c a c	a e c c	b b e c	b e b c	c b d c	c e a c	d b c c	d d e c	e b b c	e d d c						
a c a d	a e c d	b b e d	b e b d	c b d d	c e a d	d b c d	d d e d	e b b d	e d d d						
a c a e	a e c e	b b e e	b e b e	c b d e	c e a e	d b c e	d d e e	e b b e	e d d e						
a c b a	a e d a	b c a a	b e c a	c b e a	c e b a	d b d a	d e a a	e b c a	e d e a						
a c b b	a e d b	b c a b	b e c b	c b e b	c e b b	d b d b	d e a b	e b c b	e d e b						
a c b c	a e d c	b c a c	b e c c	c b e c	c e b c	d b d c	d e a c	e b c c	e d e c						
a c b d	a e d d	b c a d	b e c d	c b e d	c e b d	d b d d	d e a d	e b c d	e d e d						
a c b e	a e d e	b c a e	b e c e	c b e e	c e b e	d b d e	d e a e	e b c e	e d e e						

a. Since each inflection marker M can only be associated with one specification of morpho-syntactic features (because of **Syncretism**), it follows that for each inflection marker M and for each inflection class I, it must be the case that M is either *compatible* with I or *incompatible* with I.
b. A marker is compatible with an inflection class I if it bears no inflection class feature, if it bears fully specified inflection class information that completely characterizes I, or if it is characterized by a set of underspecified inflection class features that is a subset of the fully specified set of features that characterize the inflection class.
c. M is *activated* for I if it is compatible with it; and *deactivated* for I if it is incompatible with it.
(If a marker is activated for an inflection class I, this does not imply that it will actually be used by I – there may well be a more specific marker that blocks it.)
d. **Blocking** ensures that each inflection class can be defined in terms of the markers that are active in it: For all competing markers α and β, it is fixed once and for all by the markers' feature specifications (and independently of inflection classes) that either β is more specific than α, or α is more specific than β.
e. Hence, if the same set of markers is activated for two inflection classes I_1 and I_2, I_1 must be identical to I_2.
f. Conversely, since every marker is either activated or deactivated for any given inflection class, it also follows that if the same set of markers is *deactivated* for two inflection classes I_1 and I_2, I_1 and I_2 must be the same inflection class (because the same set of markers is then activated for I_1 and I_2, because a marker /x/ can only have one specification [ξ], and because specificity relations among competing markers are fixed).
g. In order to determine the maximal number of inflection classes on the basis of a given inventory of markers, it now suffices to successively deactivate all possible marker combinations.
h. Starting with the full inventory of markers, we can proceed by successively deactivating all combinations of markers, which yields class after class.
i. Thus, all markers of the inventory are compatible with class I_1; all except for marker *a* are compatible with class I_2; all except for markers *a, b* are compatible with class I_3; and so forth.
j. However, by assumption (**Elsewhere**), one marker always is the elsewhere (default) marker: It is compatible with all inflection classes because it is radically underspecified; and therefore it cannot be deactivated by definition.
k. Consequently, all possible *marker deactivation combinations* are provided by the *powerset* of the set of all the markers of the inventory minus the elsewhere marker: 2^{n-1}, for n markers.
l. Thus, given a set of n inflection markers, there can be at most 2^{n-1} marker deactivation combinations.
m. Since marker deactivation combinations fully determine possible inflection classes, it now follows that given a set of n inflection markers, there can be at most 2^{n-1} inflection classes.

Note:
This reasoning is independent of the number of instantiations of the grammatical category

(e.g., the number of cases) that a set of markers needs to distribute over. In contrast to what is the case under the No Blur Principle, an increase in instantiations of a grammatical category does not induce an increase in possible inflection classes over a given inventory of markers. Hence:

(30) *Inflection Class Economy Theorem*:
Given a set of n inflection markers, there can be at most 2^{n-1} inflection classes, independently of the number of grammatical categories that the markers have to distribute over.

7. Examples

7.1. A First Example

Note:
In order to illustrate the possible marker deactivation patterns, the case categories are now called *1*, *2*, *3*, and *4*. Given an inventory of three markers, there are $2^{3-1} = 4$ deactivation combinations.

(31) *Example 1 revisited*:
a. 3 markers: {a, b, c}
b. 4 cases: 1, 2, 3, 4
c. Deactivation combinations: { {b, c}, {b}, {c}, {} }

Observation:
Of the 81 inflection classes that would logically be possible under, only four remain, given Syncretism, Underspecification, and Blocking (i.e., the Inflection Class Economy Theorem). This result holds under any specificity-induced order of the markers, and under any assignment of case features to markers.

(32) *A possible assignment of case specifications to markers*:
a. Markers:
(i) /a/ ↔ [ ]
(ii) /b/ ↔ [12]
(iii) /c/ ↔ [234]
b. Specificity:
/b/ > /c/ > /a/
c. Deactivation combinations and inflection classes:
{b, c} → aaaa
{b} → accc
{c} → bbaa
{ } → bbcc

(33) *Another possible assignment of case specifications to markers*:
a. Markers:
(i) /a/ ↔ [ ]
(ii) /b/ ↔ [234]
(iii) /c/ ↔ [4]

b. Specificity:
/c/ > /b/ > /a/
c. Deactivation combinations and inflection classes:
{b, c} → aaaa
{b} → aaac
{c} → abbb
{ } → abbc

Note:
The question of how the cases 1, 2, 3, 4 are derived from more primitive decomposed features (e.g., how [234] can be a natural class), and how systems with apparently unnatural classes (under minimal decomposition) are derived, is orthogonal.

7.2. A second example

(34) *Example 3 revisited*:

a. 5 markers: {a, b, c, d, e}
b. 4 cases: 1, 2, 3, 4

(35) *A possible choice*:

a. Markers:
(i) /a/ ↔ [ ]
(ii) /b/ ↔ [23]
(iii) /c/ ↔ [14]
(iv) /d/ ↔ [3]
(v) /e/ ↔ [34]
b. Specificity:
/d/ > /e/ > /c/ > /b/ > /a/
c. Deactivation combinations & inflection classes:
{b, c, d, e} → aaaa
{b, c, d} → aaee
{b, c, e} → aada
{b, c} → aade
{b, d, e} → caac
{b, d} → caee
{b, e} → cadc
{b} → cade
{c, d, e} → abba
{c, d} → abee
{c, e} → abda
{c} → abde
{d, e} → cbbc
{d} → cbee
{e} → cbdc
{ } → cbde

(36) *Another possible choice*:

a. Markers:
(i) /a/ ↔ [ ]
(ii) /b/ ↔ [ ]
(iii) /c/ ↔ [1]
(iv) /d/ ↔ [2]
(v) /e/ ↔ [34]
b. Specificity:
/c/ > /d/ > /e/ > /b/ > /a/
c. Deactivation combinations & inflection classes:
{b, c, d, e} → aaaa
{b, c, d} → aaee
{b, c, e} → adaa
{b, c} → adee
{b, d, e} → caaa
{b, d} → caee
{b, e} → cdaa
{b} → cdee
{c, d, e} → bbbb
{c, d} → bbee
{c, e} → bdbb
{c} → bdee
{d, e} → cbbb
{d} → cbee
{e} → cdbb
{ } → ~~cdee~~

(37) *A third possible choice*:

a. Markers:
(i) /a/ ↔ [ ]
(ii) /b/ ↔ [234]
(iii) /c/ ↔ [134]
(iv) /d/ ↔ [123]
(v) /e/ ↔ [123]
b. Specificity:
/d/ > /e/ > /c/ > /b/ > /a/
c. Deactivation combinations & inflection classes:
{b, c, d, e} → aaaa
{b, c, d} → eeea
{b, c, e} → ddda
{b, c} → ~~ddda~~
{b, d, e} → cacc
{b, d} → eeec
{b, e} → dddc
{b} → ~~dddc~~
{c, d, e} → abbb
{c, d} → eeeb
{c, e} → dddb
{c} → ~~dddb~~
{d, e} → cbcc
{d} → ~~eeec~~
{e} → ~~dddc~~
{ } → ~~dddc~~

(38) *A fourth possible choice*:

a. Markers:
(i) /a/ ↔ [ ]
(ii) /b/ ↔ [1]
(iii) /c/ ↔ [2]
(iv) /d/ ↔ [3]
(v) /e/ ↔ [4]
b. Specificity:
/e/ > /d/ > /c/ > /b/ > /a/
c. Deactivation combinations & inflection classes:
{b, c, d, e} → aaaa
{b, c, d} → aaae
{b, c, e} → aada
{b, c} → aade
{b, d, e} → acaa
{b, d} → acae
{b, e} → acda
{b} → acde
{c, d, e} → baaa
{c, d} → baae
{c, e} → bada
{c} → bade
{d, e} → bcaa
{d} → bcae
{e} → bcda
{ } → bcde

Note:
Again, the issue of what the decomposed case and inflection class features that encode the deactivation patterns in systems like (35)–(38) would actually look like is strictly speaking orthogonal to present concerns. Still, for the case at hand, in the worst case there would have to be four binary inflection class features [±α], [±β], [±γ] and [±δ] whose cross-classification yields the sixteen inflection classes (with individual markers underspecified as, e.g., [+α]); two abstract grammatical category features (e.g., case features such as [±governed], [±oblique], as in Bierwisch (1967)) would suffice for all systems but (37), where either reference to negated specifications would be necessary, or a third primitive feature would have to be invoked.

8. Conclusion

Scope of the result:
There may be minor imperfections in inflectional systems that can be traced back to historical factors. In particular, these deviations from optimal design show up in the form of isolated markers that cannot be given unique specifications, resulting in a case of *non-systematic homophony*. In such a situation, the set of possible inflection classes is mildly increased; it is 2^{n-1+x}, for x additional marker specifications required by unresolved, accidental homophony.

Abstractness of inflection markers:
The notion of "marker" is to be understood in a somewhat more abstract way that ignores allomorphic variation which is phonologically or morpho-phonologically conditioned (and not morphologically, as with variation determined by inflection class membership). For instance, Halle (1994) argues that the marker realizations *ov* and *ej* for genitive plural in Russian are allomorphs whose choice is morpho-phonologically determined; on this view, there is but a single marker /ov/, accompanied a single underspecified set of morpho-syntactic features (perhaps involving underspecified inflection class features, as suggested in Alexiadou & Müller (2008) in order to account for fact that this marker exhibits trans-paradigmatic syncretism).

Note:
The same reasoning applies to
(i) the use of *disjunction* or *negation* in marker specifications (see, e.g., Bierwisch (1967), Wunderlich (1996)), but only if contradictory feature specifications are involved;
(ii) the use of variables over feature values in marker specifications (i.e., α notation (see Chomsky (1965), Chomsky & Halle (1968) for the original concept, Noyer (1992), Harley (1994), Johnston (1996), Börjesson (2006), Georgi (2006), Lahne (2006), Opitz (2006) and Alexiadou & Müller (2008) on its use in morphology).

On the other hand:
The 2^{n-1} formula captures worst case scenarios. Overlapping marker specifications reduce the number of possible inflection classes further. Moreover, for an inflectional system to fully exploit the logical possibilities for developing inflection classes as they arise under the Inflection Class Economy Theorem is extremely unlikely – typically, far from all marker deactivation combinations will be employed.

(39) *Consequences for other morphological operations*:

a. *Fission* (Distributed Morphology; Halle & Marantz (1993), Noyer (1992)), *rule blocks* (stem-and-paradigm accounts; Anderson (1992), Stump (2001)). Both concepts give rise to instances of subanalysis, in the sense that what may look like a complex marker at first sight turns out to be best analyzed as a sequence of smaller markers, each with its own specifications (Janda & Joseph (1992), Bierkandt (2006)): unproblematic as long as it is understood that no more than one inflection class can determine a sequence of subanalyzed markers in each case.

b. *Impoverishment* (Distributed Morphology): Given that standard impoverishment (as feature deletion) can be reanalyzed as insertion of a highly specific null marker (Trommer (1999)), each impoverishment rule also increases the set of n's (for which the powerset is created) by one.

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