Quantitative and Qualitative Aspects of Paradigm Economy in Lesser Studied Languages

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1. Introduction

Background

Strategy:
Systematic accounts of as many instances of syncretism as possible: one form – one function (i.e., feature specification).

Consequence:
Abstractness of morphological analyses of paradigms:

- underspecification of exponents
- competition of exponents (and principles that resolve the competition)
- abstract features on exponents encoding natural classes (like [oblique], [local person])
- subanalysis of exponents: obvious in some cases, possible in many more cases (e.g., *du*, *dich* = /d/-/u:/, /d/-/ɪ/-/ç/; see Pike (1965), Wiese (2001), Fischer (2006)).

Question:
Is there independent evidence for such an approach?

Claim (Müller (2007)):
Yes: If syncretism is systematic in the unmarked case, a version of paradigm economy comes for free (the *Inflection Class Economy Theorem*).

Carstairs-McCarthy's Constraints

(1) *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.

(2) *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.

Problem

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* (see Halle (1992), Oltra Massuet (1999), Stump (2001), Alexiadou & Müller (2008), and below).

(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.)

Strategies

Two possible strategies:

1. argue that the question of how inflection classes can be constrained is irrelevant from a synchronic perspective;
2. 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.

2. The Inflection Class Economy Theorem

Inflection Class Economy Theorem

(3) *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 in Müller (2007)

Claim:
The Inflection Class Economy Theorem follows under any morphological theory that makes the three assumptions in (4), (5), and (6): 'Syncretism', 'Elsewhere', and 'Blocking'.

(Throughout, we 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)).)

Syncretism

(4) *Syncretism* (first assumption):
Identity of form implies identity of function: For each marker, there is a unique specification of morpho-syntactic features.
(within a certain domain, and unless there is evidence to the contrary).

Note:

- The Syncretism Principle in (4) 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.
- Pertsova's (2007) threepart learning algorithm for inflectional systems (No-Homonymy Learner > Elsewhere Learner > General Homonymy Learner) presupposes the Syncretism Principle in (4).
- The Syncretism Principle in (4) is a standard research strategy for linguistic fieldwork.

Elsewhere

(5) *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).

Blocking

(6) *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

Consequence:

1. Syncretism is systematic in the sense that only one specification of morpho-syntactic features is associated with any given inflection marker (with the qualifications mentioned above).
2. For any given fully specified context, there is always one inflection marker that fits.
3. 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).)

Questions:

- How does the Inflection Class Economy Theorem constrain inflectional systems?
- How does the Inflection Class Economy Theorem follow as a theorem from Syncretism, Elsewhere, and Blocking?

Basic Question

(7) *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:
(7-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 (7-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).

Comments on Example 1

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.

Explanation of Worst Case Scenarios 1

(8) *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.

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				

Explanation of Worst Case Scenarios 2

(9) *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.

Explanation of Worst Case Scenarios 3

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*.

Predictions for Example 1

(10) 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}

Another Abstract Example

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			

Predictions for Example 2

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

b. No Blur Principle, worst case scenario:
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}

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.

3. Deriving the Inflection Class Economy Theorem

Assumptions

Recall:

1. Syncretism: Only one morpho-syntactic feature specification is associated with each marker of the inventory for a given morphological domain (exceptions apart).

2. Elsewhere: There is always one marker that in principle fits into every context of fully specified morpho-syntactic features.

3. Blocking: There is always only one marker that can in fact be used for any fully specified context of morpho-syntactic features.

Marker Deactivation Combinations

(12) *Argument* (extremely short version):

a. Each inflection marker M can only be associated with one specification of morpho-syntactic features (**Syncretism**).
b. 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; in the latter case, the marker is *deactivated* for I.
c. Specificity relations between exponents are invariant (**Blocking**)
d. Inflection classes are unambiguously characterized by *marker deactivation combinations*.
e. One inflection marker cannot be deactivated (**Elsewhere**).
f. The set of all possible *marker deactivation combinations* is the *powerset* of the set of all the markers of the inventory minus the elsewhere marker: 2^{n-1}, for n markers.
g. Marker deactivation combinations fully determine possible inflection classes. Hence: Given a set of n inflection markers, there can be at most 2^{n-1} inflection classes.

Inflection Class Economy as A Theorem

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:

(13) *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.

4. Abstract Examples

The 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.

(14) *Example 1 revisited*:

a. 3 markers: {a, b, c}
b. 4 cases: 1, 2, 3, 4
c. Deactivation combinations: { {b, c}, {b}, {c}, {} }

The First Example 2

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.

(15) *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

5. Distinguishing between the Theories

State of the Art

- The Paradigm Economy Principle, the No Blur Principle and Inflection Class Economy Theorem all impose *quantitative* restrictions on the number of a priori possible inflection classes on the basis of a given inventory of inflectional exponents (but the Inflection Class Economy Theorem does not have to be stipulated).
- The No Blur Principle also imposes severe *qualitative* restrictions on possible inflection classes on the basis of a given inventory that turn out to be too strong.

No Blur's Qualititative Restrictions Are Too Strong 1

(16) *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	v ík-Ø
acc/sg	vél-Ø	drottning-u	mynd-Ø	geit-Ø	v ík-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

Claim (Carstairs-McCarthy (1994, 740-742)):
The systems adheres to No Blur:

- No Blur only holds within a given gender.
- Even in genitive singular and nominative plural contexts, there is only one exponent that fails to unambiguously identify inflection class.

No Blur's Qualititative Restrictions Are Too Strong 2

Observation:
No Blur makes wrong predictions if the *complete* system of Icelandic noun declension is taken into

account (Kress (1982), Müller (2005)). Hardly any of the genitive singular or nominative plural markers unambiguously identifies and inflection class (the exceptions are *ur* und *u* in the genitive singular, and Ø and *u* in the nominative plural). Even if the No Blur Principle only holds for inflection classes of the same gender, it cannot hold here: In masculine nominative plural contexts, neither *ar* nor *ir* unambiguously identifies inflection class: The former marker shows up in Ma and Mw, the latter in Mi and Mu.

(17) *The complete system of inflection classes in Icelandic noun inflection*

	I Ma	II Na	III Fa(′)	IV Mi	V Fi	VI Mu	VII Mc	VIII Fc1	IX Fc2	X Mw	XI Nw	XII 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

Note: The problem is a *qualitative* one, not a *quantitative* one: Given the number of exponents in the case/number inventory, No Blur would permit much more than 12 inflection classes – it just excludes a system with the ones that we find.

6. Case Studies

Paradigm Economy and Lesser Studied Languages

Goal:

- Most of the evidence for or against the various concepts of paradigm economy has come from well-studied (often Indo-European) languages.
- We focus on paradigm economy in systems with many inflection classes in lesser studied languages (all from New Guinea):
  1. *Amele*
  2. *Anêm*
  3. *Arapesh*

Claims:

- There are *quantitative* problems for the Paradigm Economy Principle.
- There are *qualitative* problems for the No Blur Principle.
- There are apparent reverse *quantitative* problems for the Inflection Class Economy Theorem: Too many inflectional classes seem to be permitted.
- This problem for the Inflection Class Economy Theorem disappears because closer srutiny reveals the number of exponents in the inventory to be much smaller: *subanalysis*.

6.1 Amele

Amele Data
Roberts (1987) lists 31 inflection classes for possession marking on inalienable nouns in Amele (Trans-New Guinea; Northern Papua New Guinea). Taking into account variation that is phonologically conditioned, the system in (18) results, which has *23 inflection classes*. (Neither phonological nor semantic information can account for the distribution from a synchronic perspective.)

(18) Amele Possessive Inflection Classes

	1	4	5	6	7	8	9	11	13	14
1s	ni	ni	eni	ni	ni	mi	ni	ni	ni	ni
2s	n	n	ein	n	in	m	n	n	in	in
3s	g	ug	ug	nag	nug	g	n	c	c	ic

	16	17	18	19	22	23	25	26	27	28	29	30	31
1s	mi	mi	mi	ni	ini	ani	ni	li	i	i	i	i	i
2s	im	m	im	n	inin	ain	in	in	in	im	in	in	en
3s	c	h	h	Ø	Ø	Ø	ig	ig	ig	ig	iag	ag	eg

Predictions for Amele
There are 27 different markers for 3 instantiations of grammatical categories (1sg, 2sg, 3sg) that are distributed over 69 cells.

(19) a. Paradigm Economy Principle, worst case scenario:
13 inflection classes: the number of markers for the 3rd person singular.
b. No Blur Principle, worst case scenario:
79 inflection classes: ((27-1)×3)+1
c. Inflection Class Economy Theorem, worst case scenario:
67 108 864 inflection classes: 2^{27-1}

Note:
No Blur makes wrong qualitative predictions by postulating that in every grammatical category only one marker can fail to unambiguously identify inflection class. This is obviously not the case in Amele (eg. *ni* and *mi* in 1s; *in* and *n* in 2s; and Ø and *ig* in 3s).

Amele Data: A Closer Look

Recombination of the same inflectional material again and again:

(20) Amele Possessive Inflection Classes

	1	4	5	6	7	8	9	11	13	14
1s	*ni*	*ni*	e*ni*	*ni*	*ni*	*mi*	*ni*	*ni*	*ni*	*ni*
2s	*n*	*n*	e*in*	*n*	*in*	*m*	*n*	*n*	*in*	*in*
3s	*g*	u*g*	u*g*	*nag*	*nug*	*g*	*n*	c	c	*ic*

	16	17	18	19	22	23	25	26	27	28	29	30	31
1s	*mi*	*mi*	*mi*	*ni*	*ini*	a*ni*	*ni*	l*i*	*i*	*i*	*i*	*i*	*i*
2s	*im*	*m*	*im*	*n*	*inin*	a*in*	*in*	*in*	*in*	*im*	*in*	*in*	e*n*
3s	c	h	h	Ø	Ø	Ø	*ig*	*ig*	*ig*	*ig*	*iag*	a*g*	e*g*

- subanalysis of complex markers into more primitive ones (with often segment-like size)

- natural classes of inflection classes showing up through marker syncretism
- resulting in only 10 inflection markers

Predictions for Amele (revised)

(21) a. Paradigm Economy Principle, worst case scenario:
9 inflection classes: the number of markers for the 3rd person singular
b. No Blur Principle, worst case scenario:
28 inflection classes: ((10-1)×3)+1
c. Inflection Class Economy Theorem, worst case scenario:
512 inflection classes: 2^{10-1}

Note:

- Still the No Blur Principle makes wrong qualitative predictions and furthermore cannot capture the massive inter class syncretism: No Blur is inherently incompatible with transparadigmatic syncretism.
- Given subanalysis (which is linguistically motivated and derives the syncretism patterns in (20)), the number of possible inflection classes predicted by the Inflection Class Economy Theorem is significantly reduced. Both qualitatively and quantitatively, the system in (20) is compatible with this theorem.

Sketch of an Analysis

The marker (under)specifications would roughly be the ones in (22) to account for Amele.

(22) *Exponents in Amele Possession Marking*:
/n/ ↔ [1,2]
/m/ ↔ [1,2; {VI, XI, XII, XIII, XX}]
/g/ ↔ [3; {I, II, III, IV, V, VI, XVII, XVIII, XIX, XX, XXI, XXII, XXIII}]
/∅/ ↔ [3; {XIV, XV, XVI}]
/h/ ↔ [3; {XII, XIII}]
/c/ ↔ [3; {VIII, IX, X, XI}]
/i/ ↔ [ ]

- The vowels *a*, *e* and *u* realise specific class features not used for *g* or ∅.
- At least one impoverishment rule must be assumed. This rule deletes person information in 1s in the classes {XIX, XX, XXI, XXII, XXIII} in order to account for the sole *i*.
(Each impoverishment rule increases the set of *n*'s (for which the powerset is created) by one, given Trommer's (1999) approach in terms of highly specific null markers.)

Note: { } in (22) indicates a natural class of inflection classes.

6.2 Natural Classes of Inflection Classes

Natural Classes of Inflection Classes

- Inflection class features are not primitives. They can be decomposed into even smaller (binary) features (e.g., $[\alpha]$, $[\beta]$).

- Cross-classification of these smaller features makes up the inflection classes (eg. class 1: $[+\alpha+\beta]$; class 2: $[+\alpha-\beta]$; class 3: $[-\alpha+\beta]$; class 4: $[-\alpha-\beta]$).
- Inflection markers can then be underspecified for inflection class (e.g., a marker bears only $[+\alpha]$ and, given the Subset Principle, is thus compatible with class 1 and class 2).
- Inflection classes that share at least one primitive feature form a natural class of inflection classes, which is defined by this very feature (eg. class 1 and class 2 form a natural class of inflection classes which is defined by $[+\alpha]$).

Refs.:
Halle (1992), Oltra Massuet (1999), Wiese (1999), Stump (2001), Alexiadou & Müller (2008), Müller (2005), Trommer (2005), Opitz (2006), Weisser (2006).

Warembori: An Analysis

(23) *Transparadigmatic Syncretism with Subject Agreement Markers in Warembori* (Lower Mamberamo, New Guinea; Donohue (1999), Hein (2008))

		Inflection Classes				
		I	II	III	IV	V
SG	1.	*i-*	∅(*e*)-	*e-*	*e-*	ya-
	2.	u-/a-	w(a)-	a-	a-	a-
	3.	*i-*	y(a)-	*i-*	∅-	∅-
NSG	1.EXC	am *i-*	am(a)-	ame-	am *i-*	am *i-*
	1.INC	k *i-*	k(a)-	ke-	k *i-*/ke-	k *i-*
	2.	m *i-*	m(a)-	me-	m *i-*/me-	m *i-*
	3.	t *i-*	t(a)-	te-	t *i-*/te-	t *i-*

/k/↔[+1, +2]
/m/↔[+2, −sg]
/am/↔[+1, −sg]
/wa/↔[+2, $-\alpha, +\beta, -\gamma$]
/ya/↔[ℵ1, ℵα, −ℵβ]
(/u/↔[+2, $-\alpha, -\beta$])
/e/$_1$↔[+1, $+\beta$]
/a/$_1$↔[+2]
/i/$_1$↔[+sg, ℵα, −ℵγ]
/∅/↔[+sg]
/a/$_2$↔[$-\alpha, +\beta$]
/i/$_2$↔[$+\gamma$]
/e/$_2$↔[$+\beta$]
/t/↔[ ]

(24) Decomposition of Inflection Class Features
I: $[-\alpha, -\beta, +\gamma]$
II: $[-\alpha, +\beta, -\gamma]$
III: $[+\alpha, +\beta, -\gamma]$
IV: $[+\alpha, +\beta, +\gamma]$
V: $[+\alpha, -\beta, +\gamma]$
?: $[+\alpha, -\beta, -\gamma]$
?: $[-\alpha, +\beta, +\gamma]$
?: $[-\alpha, -\beta, -\gamma]$

6.3 Anêm

Anêm Data

Thurston (1980)1 lists the 20 inflection classes (noun classes) shown in (25) for the declension of possessive noun phrases in Anêm (East Papuan; West New Britain, Papua New Guinea). A possessive noun phrase has the form in (25).

(25) stem + stem extender + possessive suffix

- A noun can show up in different inflection classes, with different meanings.

- However, inflection class membership of nouns cannot be predicted on the basis of the noun's semantic properties: The classes are not semantically homogeneous.

Anêm Paradigms

(26) Anem Possessive Inflection Classes

	1	2	3	4	5	6	7	8	9	10
1s	-ɪ	-n-aɪ	-l-ɪ	-ɪ	-s-ɪ	-u-ɪ	-e	-l-e	-l-e	-ng-e
1p.inc	-ɪng	-n-ɪng	-l-ɪng	-ɪng	-s-ɪng	-u-ɪng	-eng	-l-eng	-l-eng	-ng-eng
1p.exc	-în	-n-în	-l-în	-în	-s-în	-u-în	-ên	-l-ên	-l-ên	-ng-ên
2s	-î	-n-î	-l-ɪr	-ɪr	-s-ɪr	-u-î	-ê	-l-ê	-l-er	-ng-ê
2p	-îng	-n-îng	-l-îng	-îng	-s-îng	-u-îng	-êng	-l-êng	-l-êng	-ng-êng
3masc	-u	-n-u	-l-u	-u	-s-u	-u-u	-o	-l-o	-l-o	-ng-o
3fem	-îm	-n-îm	-l-îm	-îm	-s-îm	-u-îm	-êm	-l-êm	-l-êm	-ng-êm
3p	-î	-n-î	-l-î	-î	-s-î	-u-î	-ê	-l-ê	-l-ê	-ng-ê

	11	12	13	14	15	16	17	18	19	20
1s	-k-e	-ak-e	-a	-k-a	-g-a	-at	-ɪat	-d-at	-m-at	-mo
1p.inc	-k-eng	-ak-eng	-ɪng	-k-ɪng	-g-ɪng	-nɪs	-nɪs	-d-nɪs	-m-nɪs	-mo-nɪs
1p.exc	-k-ên	-ak-ên	-în	-k-în	-g-în	-nɪt	-nɪt	-d-nɪt	-m-nɪt	-mo-nɪt
2s	-k-ê	-ak-ê	-îr	-k-îr	-g-îr	-ɪr	-ɪr	-d-ɪr	-m-îr	-mo-r
2p	-k-êng	-ak-êng	-îng	-k-îng	-g-îng	-ngît	-ngît	-d-ngît	-m-ngît	-mo-ngît
3masc	-k-o	-ak-o	-î	-k-î	-g-î	-ɪt/-ɪl	-ɪt/-ɪl	-d-ɪt/-î	-m-ît/-îl	-mo-t/-l
3fem	-k-êm	-ak-êm	-î	-k-î	-g-î	-ɪt/-ɪl	-ɪt/-ɪl	-d-ɪt/-î	-m-ît/-îl	-mo-t/-l
3p	-k-ê	-ak-ê	-ɪ	-ɪ	-ɪ	-ɪt/-ɪl	-ɪt/-ɪl	-d-ɪt/-î	-m-ît/-îl	-mo-t/-l

Predictions for Anêm

There are (up to) 42 different inflection markers distributed over 8 instantiations of grammatical categories (encoding person and number) in 20 inflection classes.

(27) a. Paradigm Economy Principle, worst case scenario:
20 inflection classes: the number of markers for the 3rd person singular masculine
b. No Blur Principle, worst case scenario:
329 inflection classes: ((42-1)×8)+1
c. Inflection Class Economy Theorem, worst case scenario:
2 199 023 255 552 inflection classes: 2^{42-1}

Note:

- Again No Blur makes wrong qualitative predictions by postulating that in every grammatical category only one marker can fail to unambiguously identify inflection class. And yet again this is not the case in Anêm (eg. *-k-* and *-l-* in all persons or *-îng* and *-êng* in all persons).

- Given subanalysis (which is linguistically motivated and derives the syncretism patterns in (26)), the number of possible inflection classes predicted by the Inflection Class Economy Theorem is significantly reduced. Both qualitatively and quantitatively, the system in (26) is compatible with this theorem.

Anêm Data: A Closer Look

(28) Anem Possessive Inflection Classes

	1	2	3	4	5	6	7	8	9	10
1s	-*ɪ*	-n-aɪ	-l-*ɪ*	-*ɪ*	-s-*ɪ*	-u-*ɪ*	-*e*	-l-*e*	-l-*e*	-ng-*e*
1p.inc	-*ɪng*	-n-*ɪng*	-l-*ɪng*	-*ɪng*	-s-*ɪng*	-u-*ɪng*	-*eng*	-l-*eng*	-l-*eng*	-ng-*eng*
1p.exc	-*în*	-n-*în*	-l-*în*	-*în*	-s-*în*	-u-*în*	-*ên*	-l-*ên*	-l-*ên*	-ng-*ên*
2s	-*î*	-n-*î*	-l-*ɪr*	-*ɪr*	-s-*ɪr*	-u-*î*	-*ê*	-l-*ê*	-l-*er*	-ng-*ê*
2p	-*îng*	-n-*îng*	-l-*îng*	-*îng*	-s-*îng*	-u-*îng*	-*êng*	-l-*êng*	-l-*êng*	-ng-*êng*
3masc	-u	-n-u	-l-u	-u	-s-u	-u-u	-o	-l-o	-l-o	-ng-o
3fem	-*îm*	-n-*îm*	-l-*îm*	-*îm*	-s-*îm*	-u-*îm*	-*êm*	-l-*êm*	-l-*êm*	-ng-*êm*
3p	-*î*	-n-*î*	-l-*î*	-*î*	-s-*î*	-u-*î*	-*ê*	-l-*ê*	-l-*ê*	-ng-*ê*

	11	12	13	14	15	16	17	18	19	20
1s	-k-*e*	-ak-*e*	-a	-k-a	-g-a	-at	-ɪat	-d-at	-m-at	-mo
1p.inc	-k-*eng*	-ak-*eng*	-*ɪng*	-k-*ɪng*	-g-*ɪng*	-nɪs	-nɪs	-d-nɪs	-m-nɪs	-mo-nɪs
1p.exc	-k-*ên*	-ak-*ên*	-*în*	-k-*în*	-g-*în*	-nɪt	-nɪt	-d-nɪt	-m-nɪt	-mo-nɪt
2s	-k-*ê*	-ak-*ê*	-*îr*	-k-*îr*	-g-*îr*	-ɪr	-ɪr	-d-ɪr	-m-îr	-mo-r
2p	-k-*êng*	-ak-*êng*	-*îng*	-k-*îng*	-g-*îng*	-ngît	-ngît	-d-ngît	-m-ngît	-mo-ngît
3masc	-k-o	-ak-o	-*î*	-k-*î*	-g-*î*	-ɪt/-ɪl	-ɪt/-ɪl	-d-ɪt/-î	-m-ît/-îl	-mo-t/-l
3fem	-k-*êm*	-ak-*êm*	-*î*	-k-*î*	-g-*î*	-ɪt/-ɪl	-ɪt/-ɪl	-d-ɪt/-î	-m-ît/-îl	-mo-t/-l
3p	-k-*ê*	-ak-*ê*	-*ɪ*	-*ɪ*	-*ɪ*	-ɪt/-ɪl	-ɪt/-ɪl	-d-ɪt/-î	-m-ît/-îl	-mo-t/-l

Predictions for Anêm (revised)

This suggests

- subanalysis of complex markers into more primitive ones

- natural classes of inflection classes

leaving 27 different markers.

(29) a. Paradigm Economy Principle, worst case scenario:
17 inflection classes: the number of markers for the 3rd person singular feminine
b. No Blur Principle, worst case scenario:
209 inflection classes: ((27-1)×8)+1
c. Inflection Class Economy Theorem, worst case scenario:
67 108 864 inflection classes: 2^{27-1}

Note:
The No Blur Principle continues to makes wrong qualitative predictions and furthermore cannot capture the massive inter class syncretism. In contrast, the Inflection Class Economy Theorem allows for markers to be underspecified and the syncretism in (28) is thus expected.

Sketch of an Analysis

The syntactic structure on which the morphology operates will have to provide three morphemes (following Distributed Morphology), one for the stem extender, one for the theme vowel and one for person and number morphemes.

(30)

/n/ ↔ [II]	/ɪ∼î/ ↔ [{I-VI, XIII-XV}]	/nɪs/ ↔ [1p.inc; {XVI-XX}]
/l/ ↔ [{III, VIII, IX}]	/e∼ê/ ↔ [{VII-XII}]	/at/ ↔ [1s; {XVI-XIX}]
/s/ ↔ [V]	/o/ ↔ [XX]	/nɪt/ ↔ [1p.exc; {XVI-XX}]
/u/ ↔ [VI]		/ngît/ ↔ [2p; {XVI-XX}]
/ng/ ↔ [X]		/t/ ↔ [3;{XVI-XX}]
/k/ ↔ [{XI, XIV}]		/l/ ↔ [3; {XVI, XVII, XIX, XX}]
/ak/ ↔ [XII]		/n/ ↔ [1p.exc]
/g/ ↔ [XV]		/ng/ ↔ [1p.exc, 2p]
/d/ ↔ [XVIII]		/m/ ↔ [fem]
/m/ ↔ [{XIX, XX}]		/u/ ↔ [masc; {I-VI}]
/∅/ ↔ [ ]		/o/ ↔ [masc; {VII-XII}]
		/r/ ↔ [2s; {III-V, IX, XIII-XX}]
		/∅/ ↔ [1s, 2s, 3p]

Note:

- Further simplification might be possible (e.g., subanalysis of /ng/ sequences, /u/ and /o/ as phonologically conditioned allomorphs); this would further reduce the marker inventory, and thus the number of possible inflection classes permitted by the Inflection Class Economy Theorem.
- However, it is **not** possible to assume three separate systems with separate inflection markers and separate inflection classes because these systems interact: One would have to postulate three kinds of class features on a given stem.

6.4 Arapesh

Arapesh Data

- Dobrin (1999) argues that gender in Woginara Arapesh (Torricelli; Western Papua New Guinea) is determined by the last segment of the singular form of the noun.
- However, there are inflection classes within some genders that are constituted by different plural suffixes (also cf. Aronoff (1994)).
- Dobrin provides the system of genders and inflection classes shown in (31).
- Gender VII is the only semantically determined one and gender VIII the default gender (that is why there are two different singular markers, nouns ending in a vowel are assigned to this gender per default).

Arapesh Paradigms

(31) Arapesh Genders and Inflection Classes

Gender	Infl-class	s	p	Gender	Infl-class	s	p
I	1	b^y	bys		14	n	ab
II	2	bŕr	ryb	VII	15	n	M
III	3	g	(ga)s	VIII	16	ñ	š
IV	4	k^u	meb		17	V	has
	5	k^u	u	IX	18	p^u	gwis
	6	k^u	rib		19	p^u	s
	7	k^u	ib	X	20	r	gu^h
	8	k^u	guhijer	XI	21	t	g^u
	9	k^u	ijer		22	t	tog^u
	10	k^u	komi	XII	23	uh-^{uh}	ruh
	11	k^u	heu		24	^{uh}	gwiruh
V	12	Vm	(e)ip^{i}	XIII	25	a^h	e^h
VI	13	n	b		26	u^h	i^h

Predictions for Arapesh

There are 41 markers distributed over 2 categories (singular and plural) in 26 inflection classes.

(32) a. Paradigm Economy Principle, worst case scenario:
26 inflection classes: the number of markers for the plural
b. No Blur Principle, worst case scenario:
81 inflection classes: ((41-1)×2)+1
c. Inflection Class Economy Theorem, worst case scenario:
1 099 511 627 776 inflection classes: 2^{40-1}

Note:
Yet again the No Blur Principle makes wrong qualitative predictions in the sense that it expects only one marker to not unambiguously identify its inflection class. This is the case in the plural; however, in the singular there are four markers that are not inflection class specific, namely k^u, *n*, p^u and *t*.

Arapesh Data: A Closer Look

(33) Arapesh Genders and Inflection Classes

Gender	Infl-class	s	p	Gender	Infl-class	s	p
I	1	b^y	bys		14	n	ab
II	2	bŕr	ryb	VII	15	n	M
III	3	g	(ga)s	VIII	16	ñ	š
IV	4	k^u	meb		17	V	has
	5	k^u	u	IX	18	p^u	gwis
	6	k^u	rib		19	p^u	s
	7	k^u	ib	X	20	r	gu^h
	8	k^u	guhijer	XI	21	t	g^u
	9	k^u	ijer		22	t	tog^u
	10	k^u	komi	XII	23	uh-^{uh}	ruh
	11	k^u	heu		24	^{uh}	gwiruh
V	12	Vm	(e)ip^{i}	XIII	25	a^h	e^h
VI	13	n	b		26	u^h	i^h

7. Conclusion

Conclusion

- The Inflection Class Economy Theorem follows from other independently motivated assumptions and is therefore a theorem.
- If we accept these assumptions (namely Syncretism, Elsewhere and Blocking) we expect markers with the same form to be one marker, even if they show up in different inflection classes.
- No Blur and the Inflection Class Economy Theorem restrict the number of possible inflection classes over a given inventory of markers in quite different ways. Both predict more inflection classes than do actually exist in the three languages. No Blur is somewhat more restrictive than the Inflection Class Economy Theorem; however, given subanalysis, the Inflection Class Economy Theorem becomes significantly more restrictive.

- No Blur restricts not only the number of the inflection classes but their form as well and cannot account for the massive transparadigmatic syncretism.
- The Inflection Class Economy Theorem follows from a system where this massive transparadigmatic syncretism is expected and explainable.

Outlook

Problem:
The hypothesis space can become quite large even under massive subanalysis.

Solution:
A further restriction: *overlapping marker specifications*.

Generalization:

- Substantial overlap of marker specifications is a characteristic of inflectional systems.
- The fewer instantiations of grammatical categories there are, the more overlap of marker specifications we can expect.

The Delimiting Case

Assumptions:

- 8 inflection markers (/a/, /b/, ..., /h/)
- 1 instantiation of a grammatical category (e.g., Spanish theme vowels): [1]
- worst case scenario under Inflection Class Economy Theorem: 127 inflection classes

(34) *Possible assignments of specifications to markers*:

a. Markers:
   (i) /a/ ↔ [ ]
   (ii) /b/ ↔ [1] or [ ]
   (iii) /c/ ↔ [1] or [ ]
   (iv) etc.

b. Specificity:
   /h/ > /g/ > /f/ > /e/ > /d/ > /c/ > /b/ > /c/ > /a/

c. Deactivation combinations and inflection classes:
   { } → /h/
   {b} → /h/
   {b,c} → /h/
   {c,d,e,g} → /h/
   etc.

Only 8 inflection classes are possible: Most marker deactivation combinations lead to inflection class redundancies. Goal for the future: develop a *stochastic algorithm* (based on typical degrees of underspecification) that captures the redundancy effect incurred by marker specification overlap.

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