Principal parts and degrees of paradigmatic transparency

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ABSTRACT

A lexeme's PRINCIPAL PARTS are a subset of the cells in its paradigm from which all of the other cells in the paradigm can be deduced. There are at least two ways of conceiving of principal parts: under the STATIC conception, the same cells in the paradigm of every lexeme are that lexeme's principal parts; under the DYNAMIC conception, the cells constituting a lexeme's principal parts may vary from one lexeme to another. We define a lexeme's paradigm as MAXIMALLY TRANSPARENT if any cell in that paradigm could function as that lexeme's sole dynamic principal part; inflection classes can be distinguished according to the kind and extent of their deviation from the ideal of maximal transparency. In general, paradigms that deviate from this ideal (i) require additional principal parts and/or (ii) admit fewer alternative principal-part analyses than would be logically possible, given their number of principal parts. We illustrate with evidence from Comaltepec Chinantec (Oto-Manguean; Mexico); drawing on a computational analysis of dynamic principal parts in this language, we demonstrate that its conjugation classes are in some instances maximally transparent and in other instances embody one or both of deviations (i) and (ii). We propose formal measures of PARADIGM PREDICTABILITY and CELL PREDICTABILITY that allow degrees of deviation to be represented precisely. We discuss the implications of our findings for the No Blur Principle (Cameron-Faulkner & Carstairs-McCarthy 2000); drawing on evidence from Fur (Nilo-Saharan; Sudan), we show that this principle cannot be maintained. Finally, we compare the principal-part systems of Comaltepec Chinantec and Fur, which demonstrate that paradigmatic transparency is an important domain of typological variation.

I. Principal parts and inflectional paradigms

It is natural to suppose that in the case of many lexemes, language users store some of the forms in an inflectional paradigm and use these stored forms as a basis for deducing the other forms in that paradigm. Given that hypothesis, how much storage should one assume? At the maximal extreme, there could be full storage; this conclusion is not implausible for highly irregular paradigms or for paradigms whose forms are exceptionally frequent. At the minimal extreme, by contrast, there could be storage of only the minimum number of forms in a paradigm that are necessary for deducing all of the paradigm's remaining forms. Principal parts embody this notion of a minimal extreme. Postulating principal parts does not, of course, commit one to the assumption that speakers store a lexeme's principal parts and nothing more, only to the assumption that they are the minimum that could be stored if unstored forms are to be deduced from stored ones.

The relation between a lexeme's principal parts and its nonprincipal parts is fundamentally analogical in nature: If the principal parts of Lexeme$_1$ and Lexeme$_2$ express the same morphosyntactic properties and are alike in form, then the nonprincipal parts of Lexeme$_1$ are analogous in form and content to those of Lexeme$_2$. For instance, given that the traditional principal parts of the Latin verb *amāre* 'love' (*amō, amāre, amāvī, amātum*) are parallel in form and content to those of *laudāre* 'praise' (cf. Table 1), their nonprincipal parts should be entirely analogous.

TABLE 1. Principal parts of five Latin verbs

Conjugation	1st person singular present indicative active	Infinitive	1st person singular perfect indicative active	Perfect passive participle (neuter nominative singular)	Gloss
1st	laudō	laudāre	laudāvī	laudātum	'praise'
2nd	moneō	monēre	monuī	monitum	'advise'
3rd	dūcō	dūcere	dūxī	dūctum	'lead'
3rd (-*iō*)	capiō	capere	cēpī	captum	'take'
4th	audiō	audīre	audīvī	audītum	'hear'

Principal parts have a long history of use in language pedagogy; generations of Latin students have learned that by memorizing a verb's four principal parts (those exemplified in Table 1), one can deduce all remaining forms in that verb's paradigm. But because principal parts are a distillation of the implicative relations that exist among the members of a lexeme's paradigm, they also reveal an important domain of typological variation in morphology.

In this paper, we use principal parts to identify a crucial dimension of this typological variation: that of PARADIGMATIC TRANSPARENCY--intuitively, the ease with which some cells in a paradigm can be deduced from other cells in that paradigm. We begin by distinguishing two types of principal-part analyses: static and dynamic (§II). Drawing upon principal-part analyses of the latter type, we develop a detailed account of paradigmatic transparency. For concreteness, we exemplify our account by reference to the conjugational system of the Comaltepec Chinantec language (§III). Some of the conjugation classes in Comaltepec Chinantec give rise to maximally transparent paradigms; most others, however, deviate from maximal transparency in one or more ways (§IV). We propose a formal measure of paradigm predictability to elucidate the degrees of such deviation (§V). The observable degrees of deviation from maximal transparency in both Comaltepec Chinantec and Fur turn out to be irreconcilable with the No-Blur Principle (§VI). At the same time, the proposed measure of paradigm predictability affords a precise account of cross-linguistic differences in paradigmatic transparency, as we demonstrate in a comparison of the conjugational systems of Comaltepec Chinantec and Fur (§VII). We summarize our conclusions in §VIII.

II. Two conceptions of principal parts

Before proceeding, we must distinguish two importantly different conceptions of principal parts in natural language.

A. *The static conception*

According to the STATIC conception of principal parts, the same sets of morphosyntactic properties identify the principal parts for every inflection class for lexemes in a given syntactic category. To illustrate, consider the hypothetical inflection-class system depicted in Table 2. In this table, there are four morphosyntactic property sets, represented as W, X, Y, and Z; there are six inflection classes, represented as Roman numerals I through VI; for each realization of a morphosyntactic property set within an inflection class, there is a particular exponent, and these exponents as represented as the letters **a** through **o**. We might represent this system of inflection classes with static principal parts as in Table 3. In this table, the shaded exponents represent the principal parts for each of the six inflection classes: The three shaded principal parts in each inflection class suffice to distinguish it from the other five inflection classes. A static system of principal parts for the set of inflection classes in Table 2 gives each lexeme belonging to the relevant syntactic category three principal parts: its realizations for the property sets W, X, and Y.

This static conception of principal parts is in fact the traditional one: The principal parts for Latin verbs in Table 1 are static, because they represent the same four morphosyntactic property sets from one inflection class to another.

TABLE 2. A hypothetical inflection-class system

	W	X	Y	Z
I	**a**	**e**	**i**	**m**
II	**b**	**e**	**i**	**m**
III	**c**	**f**	**j**	**n**
IV	**c**	**g**	**j**	**n**
V	**d**	**h**	**k**	**o**
VI	**d**	**h**	**l**	**o**

TABLE 3. Static principal parts for the hypothetical system

	W	X	Y	Z
I	**a**	**e**	**i**	**m**
II	**b**	**e**	**i**	**m**
III	**c**	**f**	**j**	**n**
IV	**c**	**g**	**j**	**n**
V	**d**	**h**	**k**	**o**
VI	**d**	**h**	**l**	**o**

(1) Sample static principal-part specifications:

Lexeme L belonging to inflection class I : L_a, L_e, L_i
Lexeme M belonging to inflection class IV : M_c, M_g, M_j
Lexeme N belonging to inflection class VI : N_d, N_h, N_l

B. The dynamic conception

According to the DYNAMIC conception of principal parts, principal parts are not necessarily parallel from one inflection class to another. The hypothetical inflection-class system in Table 2 admits the dynamic system of principal parts in Table 4. Each inflection class has only one shaded cell. If we observe that a lexeme has the exponent **a** in the form expressing the morphosyntactic property set W, we can deduce that it belongs to inflection class I; if we instead find that it has the exponent **b** in the realization of the property set W, we deduce that it belongs to inflection class II; if it exhibits the exponent **f** in the realization of property set X, we know that it belongs to inflection class III; and so forth. In a way, the dynamic conception of principal parts is more economical than the static because it allows each inflection class in this hypothetical example to have only a single principal part.

It's important to note, though, that under the dynamic conception of principal parts, the lexical specification of a lexeme's principal part must specify the morphosyntactic property set which that principal part realizes. Consider the slightly more complicated hypothetical system of inflection classes in Table 5. Here, the exponent **g** realizes the property set X in inflection class IV, but this same exponent **g** realizes the morphosyntactic property set Z in inflection class VII. In representing lexemes for this hypothetical system, it does not suffice simply to specify that a lexeme has a realization involving the exponent **g** as its principal part, because this fact fails to indicate whether that lexeme belongs to inflection class IV or inflection class VII. So lexical specifications of principal parts under the dynamic conception are pairings of morphosyntactic property sets with realizations, as in (2). We refer to such pairings as CELLS.

TABLE 4. Dynamic principal parts for the hypothetical system

	W	X	Y	Z
I	**a**	**e**	**i**	**m**
II	**b**	**e**	**i**	**m**
III	**c**	**f**	**j**	**n**
IV	**c**	**g**	**j**	**n**
V	**d**	**h**	**k**	**o**
VI	**d**	**h**	**l**	**o**

TABLE 5. Dynamic principal parts for a slightly larger system

	W	X	Y	Z
I	**a**	**e**	**i**	**m**
II	**b**	**e**	**i**	**m**
III	**c**	**f**	**j**	**n**
IV	**c**	**g**	**j**	**n**
V	**d**	**h**	**k**	**o**
VI	**d**	**h**	**l**	**o**
VII	**c**	**e**	**j**	**g**

(2) Sample dynamic principal-part specifications:

Lexeme L belonging to inflection class I : $W{:}L_a$
Lexeme M belonging to inflection class IV : $X{:}M_g$
Lexeme N belonging to inflection class VI : $Y{:}N_l$
Lexeme O belonging to inflection class VII : $Z{:}O_g$

The static and dynamic conceptions of principal parts differ in the answer they give to the question 'What are a lexeme's principal parts?' In the static approach, a lexeme's principal parts are a list of words realizing a corresponding list of morphosyntactic property sets invariant across inflection classes; but under the dynamic approach, a lexeme's principal parts are an unordered set of cells (pairings of realizations with morphosyntactic property sets).

In this paper, we restrict our attention to dynamic principal parts as the basis for our account of paradigmatic transparency. Moreover, we generally restrict our attention to optimal sets of dynamic principal parts, where a set S of dynamic principal parts is OPTIMAL for inflection class J iff there is no valid set of dynamic principal parts for J whose cardinality is less than that of S. For example, although the set of dynamic principal parts specified in (3) is perfectly valid for deducing the exponence of the four lexemes listed, it is not optimal, since the smaller set of dynamic principal parts in (2) is also valid for deducing this exponence.

(3) Sample dynamic principal-part specifications:

Lexeme L belonging to inflection class I : $W{:}L_a$, $X{:}L_e$
Lexeme M belonging to inflection class IV : $X{:}M_g$
Lexeme N belonging to inflection class VI : $Y{:}N_l$
Lexeme O belonging to inflection class VII : $Z{:}O_g$

For concreteness, we develop this account with reference to the system of dynamic principal parts embodied by the system of conjugations in Comaltepec Chinantec (Oto-Manguean; Mexico).

III. Conjugation classes in Comaltepec Chinantec

We begin with an overview of the system of conjugation classes in Comaltepec Chinantec. Verbs in Comaltepec Chinantec in general inflect for three aspects (the progressive, the intentive, and the completive) and for four person/number combinations (first person singular, first person plural, second person, and third person). These different aspects and person/number combinations are distinguished by means of the affixes represented in Table 6; these affixes are essentially constant across all of the language's sixty-seven conjugations.

TABLE 6. Inflectional paradigm of the verb 'play' (Conjugation P2B) in Comaltepec Chinantec

Aspect	1SG	1PL	2	3
Progressive	kó:^{L}-R	ko:^{M}-Rʔ	ko:^{L}-ʔ	kó:^{L}-r
Intentive	ni^{L}-kó:^{LH}-R	ni^{L}-kó^{H}-Rʔ	ni^{L}-kó:^{H}-ʔ	ni^{L}-kó^{M}-r
Completive	ka^{L}-kó^{M}-R	ka^{L}-kó^{H}-Rʔ	ka^{L}-ko:^{M}-ʔ	ka^{L}-kó:^{L}-r
(Source: Pace 1990:42)				

What distinguishes the different conjugation classes is (i) the number of syllables in a verb's stem and (ii) the prosodic characteristics of the stem. Depending upon its conjugation-class membership, a verb's stem can be monosyllabic or disyllabic; in the tables below, we represent disyllabic verb stems with the diacritic "D". The prosodic distinctions among conjugation classes are more complex; depending upon its conjugation-class membership, a stem's final syllable can have any of a range of qualities. It can vary in tone (the seven possibilities being low [L], mid [M], high [H], and the combinations [LM], [MH], [LH], and [HL]); in stress (we leave controlled stress unmarked and mark ballistic stress with [′]); in length (we leave short syllables unmarked and mark long syllables with [:]); in its capacity to trigger tone sandhi (we leave nontriggers unmarked and mark triggers as [$]); and in the presence or absence of final glottality ("open" syllables--those lacking final glottality--we leave unmarked, and checked syllables--those exhibiting final glottality--we mark with [ʔ]).

Given these syllabic and prosodic differences among the conjugation classes, one can discern three broadly different groups of conjugations. In her description of Comaltepec Chinantec verb inflection, Pace (1990) calls these three groups Class A, Class B, and Class C verbs. Class A verbs, the largest such class, are represented in Table 7. Pace (1990: 43f) distinguishes Class A verbs from verbs in the other classes by the following criteria:

> In Class A verbs, first vs. nonfirst persons are distinguished in progressive aspect. Third person may also be distinguished. The three aspects have different inflectional patterns.

Within this broad characterization of Class A verbs, there is a range of variants; thus, there are thirty-five different conjugation classes represented among the Class A verbs in Table 7.

TABLE 7. Class A conjugations in Comaltepec Chinantec

Conj	Progressive				Intentive				Completive				Sample lexemes (cited by their 2nd person completive stem)
	1sg	1pl	2	3	1sg	1pl	2	3	1sg	1pl	2	3	
P1A	M	M	L	LM	MH	H′	H′	M′	M′	H′	L′	M′	ką́^{L} ‘charge’
P1B	M	M	L	LM	MH	H′	H′	M′	M′	H′	H′	L′	tá^{H} ‘prune’
P1C	M	M	L	LM	MH	H′	H′	M′	M′	H′	L′	L′	ʔį́^{L} ‘read’
P1D	M	M	L	LM	MH	H′	H′	M′	M′	H′	H′	LM	ŋį́^{H} ‘walk’, ná^{H} ‘open’
P1E	M	M	L	LM	MH	H′	H′	M′	M′	H′	LM′	LM	ná^{LM} ‘open’
P2A	L:′	M:	L:	L:′	LH:′	H′	H:′	M′	M′	H′	M	L:′	kių^{M} ‘hit with fist’
P2B	L:′	M:	L:	L:′	LH:′	H′	H:′	M′	M′	H′	M:	L:′	ʔë:^{M} ‘kick’
P2C	L:′	M:	L:	L:′	LH:′	H′	H:′	M′	M′	H′	M:′	L:′	gí:^{M} ‘tear’
P2D	L:′	M:	L:	L:′	LH:′	H′	H:′	M′	M′	H′	L:	L:′	ke:^{L} ‘place’
P2E	L:′	M:	L:	L:′	LH:′	H′	H:′	M′	M′	H′	LH:′	L:′	ʔį́:^{LH} ‘sell’
P2F	L:′	M:	L:	L:′	LH:′	H′	H:′	M′	M′	H′	M:′	M′	tó:^{M} ‘bake’
P2G	L:′	M:	L:	L:′	LH:′	H′	H:′	M′	M′	H′	LH:′	M′	tų́:^{LH} ‘pour out’
P3A	M$ʔ′	M$ʔ′	Lʔ′	Lʔ′	Hʔ′	Hʔ′	Hʔ	Lʔ′	Mʔ′	Hʔ′	Lʔ	Lʔ′	tǫʔ^{L} ‘apply’
P3B	M$ʔ′	M$ʔ′	Lʔ′	Lʔ′	Hʔ′	Hʔ′	Hʔ	Lʔ′	Mʔ′	Hʔ′	Lʔ′	Lʔ′	húʔ^{L} ‘cough’
P3C	M$ʔ′	M$ʔ′	Lʔ′	Lʔ′	Hʔ′	Hʔ′	Hʔ	Lʔ′	Mʔ′	Hʔ′	LHʔ	Lʔ′	genʔ^{LH} ‘swing’, koʔ^{LH} ‘play with’, huënʔ^{LH} ‘speak to’
P3D	M$ʔ′	M$ʔ′	Lʔ′	Lʔ′	Hʔ′	Hʔ′	Hʔ	Lʔ′	Mʔ′	Hʔ′	LMʔ	Lʔ′	hŋanʔ^{LM} ‘kill’
P3E	M$ʔ′	M$ʔ′	Lʔ′	Lʔ′	Hʔ′	Hʔ′	Hʔ	Lʔ′	Mʔ′	Hʔ′	LMʔ′	Lʔ′	sénʔ^{LM} ‘hold’, ʔnóʔ^{LM} ‘look for’, tánʔ^{LM} ‘put into’
P3F	M$ʔ′	M$ʔ′	Lʔ′	Lʔ′	Hʔ′	Hʔ′	Hʔ	Lʔ′	Mʔ′	Hʔ′	LMʔ	Mʔ′	laʔ^{LM} ‘bathe’
P3G	M$ʔ′	M$ʔ′	Lʔ′	Lʔ′	Hʔ′	Hʔ′	Hʔ	Lʔ′	Mʔ′	Hʔ′	LMʔ′	Mʔ′	ʔnóʔ^{LM} ‘look for’
P3H	M$ʔ′	M$ʔ′	Lʔ′	Lʔ′	Hʔ′	Hʔ′	Hʔ	Lʔ′	M$ʔ′	Hʔ′	Lʔ′	Lʔ′	béʔ^{L} ‘roll up’
P3I	M$ʔ′	M$ʔ′	Lʔ′	Lʔ′	Hʔ′	Hʔ′	Hʔ	Lʔ′	M$ʔ′	Hʔ′	LMʔ	Lʔ′	koʔ^{LM} ‘play with’
P3J	M$ʔ′	M$ʔ′	Lʔ′	Lʔ′	Hʔ′	Hʔ′	Hʔ	Lʔ′	M$ʔ′	Hʔ′	LMʔ′	Lʔ′	hį́ʔ^{LM} ‘smell’
P3K	M$ʔ′	M$ʔ′	Lʔ′	Lʔ′	Hʔ′	Hʔ′	Hʔ	Lʔ′	Mʔ′	LHʔ′	LMʔ′	Lʔ′	huẽ́nʔ^{LM} ‘speak to’
P3L	M$ʔ′	M$ʔ′	Lʔ′	Lʔ′	Hʔ′	Hʔ′	Hʔ	Lʔ′	Mʔ′	LHʔ′	LMʔ′	Mʔ′	tánʔ^{LM} ‘put into’
P4A	M$ʔ′	M$ʔ′	LMʔ	LMʔ	Hʔ′	Hʔ′	Hʔ	Mʔ′	Mʔ′	Hʔ′	Lʔ′	LMʔ	ʔiénʔ^{L} ‘spray, wave’
P4B	M$ʔ′	M$ʔ′	LMʔ	LMʔ	Hʔ′	Hʔ′	Hʔ	Mʔ′	Mʔ′	Hʔ′	LHʔ	LMʔ	tënʔ^{LH} ‘drop’
P4C	M$ʔ′	M$ʔ′	LMʔ	LMʔ	Hʔ′	Hʔ′	Hʔ	Mʔ′	Mʔ′	Hʔ′	LMʔ	LMʔ	ciuʔ^{LM} ‘kiss’, ʔienʔ^{LM} ‘spray, wave’
P12A	M:	M:	L:	L:	L′	L′	L′	L′	M′	M′	M′	L:	kuán^{M} ‘grow’
P12B	M:	M:	L:	L:	L′	L′	L′	L′	M′	M′	M:′	M′	kó:^{M} ‘burn’
P12C	M:	M:	L:	L:	L′	L′	L′	L′	M′	M′	L:	M:′	ię:^{L} ‘swell’
P13A	M$ʔ′	M$ʔ′	Lʔ′	Lʔ′	Mʔ′	Mʔ′	Lʔ′	Lʔ′	Mʔ′	Mʔ′	Mʔ′	Mʔ′	rǫ́ʔ^{M} ‘bear weight of’
P13B	M$ʔ′	M$ʔ′	Lʔ′	Lʔ′	Mʔ′	Mʔ′	Lʔ′	Lʔ′	Mʔ′	Mʔ′	Lʔ′	Lʔ′	hínʔ^{L} ‘hiccough’
P16A	DM$ʔ	DMʔ	DLʔ	DLʔ′	DM$ʔ	DMʔ	DLʔ	DLʔ′	DM$ʔ	DMʔ	DLʔ	DLʔ′	hmï^{H}ʔëʔ^{L} ‘defend’
P16B	DM:	DM:	DHL:	DL′	DM:	DM:	DHL:	DL′	DM:	DM:	DHL:	DL′	hmï^{H}kių:^{HL} ‘toast, dry’
P16C	DM$ʔ	DM$ʔ	DHLʔ	DLʔ′	DM$ʔ	DM$ʔ	DHLʔ	DLʔ′	DM$ʔ	DM$ʔ	DHLʔ	DLʔ′	hmï^{L}uïʔ^{HL} ‘smooth, plane’

(Source: Pace 1990:43-46; 49-51)

Pace (1990: 46) uses the following criteria to distinguish the Class B verbs:

> In Class B verbs, only third person is distinguished in noncompletive aspects. Like Class A verbs, the three aspects have different inflectional patterns.

As Table 8 shows, this broad characterization of Class B verbs subsumes nineteen different conjugations.

TABLE 8. Class B conjugations in Comaltepec Chinantec

Conj	Progressive				Intentive				Completive				Examples
	1sg	1pl	2	3	1sg	1pl	2	3	1sg	1pl	2	3	
P5A	L′	L′	L′	L′	H′	H′	H′	L′	L′	H′	L′	L′	bá^{L} ‘hit’
P5B	L′	L′	L′	L′	H′	H′	H′	L′	L′	H′	LM′	L′	ʔá^{LM} ‘wade across’
P6A	M:′	M:′	M:′	M:′	H′	H′	H′	M:′	M:′	M:′	M′	M:′	hlḯ^{M} ‘cover’
P6B	M:′	M:′	M:′	M:′	H′	H′	H′	M:′	M:′	M:′	M:′	M:′	hnú:^{M} ‘rub against’
P6C	M:′	M:′	M:′	M:′	H′	H′	H′	M:′	M:′	M:′	LM′	M:′	hín^{LM} ‘scold’
P7A	LM′	LM′	LM′	LM′	LH′	LH′	LH′	M′	M′	LH:′	M:	LM′	kuë:n^{M} ‘give’
P7B	LM′	LM′	LM′	LM′	LH′	LH′	LH′	M′	M′	LH:′	M:′	LM′	ʔí:n^{M} ‘pardon’, hnió:n^{M} ‘drag’
P7C	LM′	LM′	LM′	LM′	LH′	LH′	LH′	M′	M′	LH:′	L:	LM′	kuë:n^{L} ‘give’
P7D	LM′	LM′	LM′	LM′	LH′	LH′	LH′	M′	M′	LH:′	L:′	LM′	hnió:n^{L} ‘drag’
P7E	LM′	LM′	LM′	LM′	LH′	LH′	LH′	M′	M′	LH:′	LH:′	LM′	ʔŋí:^{LH} ‘blow nose, spit’
P7F	LM′	LM′	LM′	LM′	LH′	LH′	LH′	M′	M′	LH:′	LM′	LM′	ʔín^{LM} ‘pardon’
P14A	L′	L′	L′	L′	L′	L′	L′	L′	L′	L′	L′	L′	tắ^{L} ‘drop’
P14B	L′	L′	L′	L′	L′	L′	L′	L′	M′	M′	M′	M′	ʔí^{M} ‘enter’
P15A	M′	M′	M′	M′	M′	M′	M′	M′	M′	M′	M′	M′	zé^{M} ‘go’
P15B	Mʔ′	Mʔ′	Mʔ′	Mʔ′	Mʔ′	Mʔ′	Mʔ′	Mʔ′	Mʔ′	Mʔ′	Mʔ′	Mʔ′	huḯnʔ^{M} ‘lazy’
PDBA	DH′	DH′	DH′	DH′	DH′	DH′	DH′	DH′	DH′	DH′	DH′	DH′	hmï^{L}ʔí^{H} ‘count’
PDBB	DHL:′	DHL:′	DHL:′	DL:′	DHL:′	DHL:′	DHL:′	DL:′	DHL:′	DHL:′	DHL:′	DL:′	hmï^{L}gó:^{HL} ‘deceive’
PDBC	DH′	DH′	DH′	DM′	DH′	DH′	DH′	DM′	DH′	DH′	DH′	DM′	hmï^{L}ʔmé^{H} ‘sharpen’
PDBD	DMHʔ	DMHʔ	DMHʔ	DLHʔ	DMHʔ	DMHʔ	DMHʔ	DLHʔ	DMHʔ	DMHʔ	DMHʔ	DLHʔ	hmï^{L}kǫʔ^{MH} ‘help’
(Source: Pace 1990:46-48; 50-51)													

Finally, Pace (1990: 48) distinguishes Class C verbs by the following criteria.

> In Class C verbs, third person is distinguished from nonthird. Aspect has different inflectional patterns in third person only.

The different variant possibilities within Class C are represented in Table 9, with thirteen different conjugations.

TABLE 9. Class C conjugations in Comaltepec Chinantec

Conj	Progressive				Intentive				Completive				Examples
	1sg	1pl	2	3	1sg	1pl	2	3	1sg	1pl	2	3	
P8A	M:	M:	M:	L:′	M:	M:	M:	M′	M:	M:	M:	L:′	ʔme:nʔ^{M} ‘hide’, na:n^{M} ‘begin’
P8B	M:	M:	M:	L:′	M:	M:	M:	M′	M:	M:	L:	L:′	na:n^{L} ‘begin’
P9A	LH:′	LH:′	LH:′	LM′	LH:′	LH:′	LH:′	M′	LH:′	LH:′	M:′	LM′	kiá:n^{M} ‘sweep’
P9B	LH:′	LH:′	LH:′	LM′	LH:′	LH:′	LH:′	M′	LH:′	LH:′	L:′	LM′	hḯ:n^{L} ‘argue’
P9C	LH:′	LH:′	LH:′	LM′	LH:′	LH:′	LH:′	M′	LH:′	LH:′	LH:′	LM′	hú:^{LH} ‘lie’, kiá:n^{LH} ‘sweep’, hḯ:n^{LH} ‘argue’
P10	LHʔ	LHʔ	LHʔ	LMʔ	LHʔ	LHʔ	LHʔ	Mʔ	LHʔ	LHʔ	LHʔ	LMʔ	hunʔ^{LH} ‘squat down’
P11	LMʔ′	LMʔ′	LMʔ′	LMʔ′	LMʔ′	LMʔ′	LMʔ′	LMʔ′	LMʔ′	LMʔ′	LMʔ′	LMʔ′	huḯnʔ^{LM} ‘tire’
PCMA	M	M	M	M	M	M	M	M	M	M	M	M	ʔiu:n^{M} ‘inside’
PCMB	LHʔ	LHʔ	LHʔ	LHʔ	LHʔ	LHʔ	LHʔ	LHʔ	LHʔ	LHʔ	LHʔ	LHʔ	niʔ^{LH} ‘open out’
PCMC	LH:′	LH:′	LH:′	LH:′	LH:′	LH:′	LH:′	LH:′	LH:′	LH:′	LH:′	LH:′	ʔí:n^{LH} ‘want’
PDCA	DM:	DM:	DM:	DM:	DM:	DM:	DM:	DM:	DM:	DM:	DM:	DM:	hmï^{L}ʔa:n^{M} ‘hungry’
PDCB	DLMʔ′	DLMʔ′	DLMʔ′	DLMʔ′	DLMʔ′	DLMʔ′	DLMʔ′	DLMʔ′	DLMʔ′	DLMʔ′	DLMʔ′	DLMʔ′	hmï^{L}ʔínʔ^{LM} ‘rest’
PDCC	DHʔ	DHʔ	DHʔ	DHʔ	DHʔ	DHʔ	DHʔ	DHʔ	DHʔ	DHʔ	DHʔ	DHʔ	hmï^{L}guänʔ^{H} ‘bless’
(Source: Pace 1990:48-51)													

We say that the paradigm P of a member of conjugation J is MAXIMALLY TRANSPARENT if each pairing of a property set with an exponent in P is unique across all conjugations to the paradigms of members of J. If lexeme L has a maximally transparent paradigm P, any cell in P can serve as L’s sole dynamic principal part.

Figure 1 represents a maximally transparent paradigm having twelve cells. The numbers 1 through 12 in this diagram represent twelve different morphosyntactic property sets; the letters *a* through *l* represent the realizations of those twelve different property sets (so that each vertex in Figure 1 is labelled as a cell); and each of the lines in this diagram represents a relation of bidirectional implication between two cells. In other words, the pairing of a realization with a morphosyntactic property set in every cell implies the pairing of a realization with a morphosyntactic property set in every other cell. If a language user has learned the implicative relations in which a maximally transparent paradigm P_1 participates, then upon learning that the paradigm P_2 of a newly encountered verbal lexeme has a cell analogous to a cell in P_1, the language user can deduce every other cell in P_2. Thus, transparency is associated with the ease with which some of the cells in a paradigm can be deduced from other cells in the same paradigm.

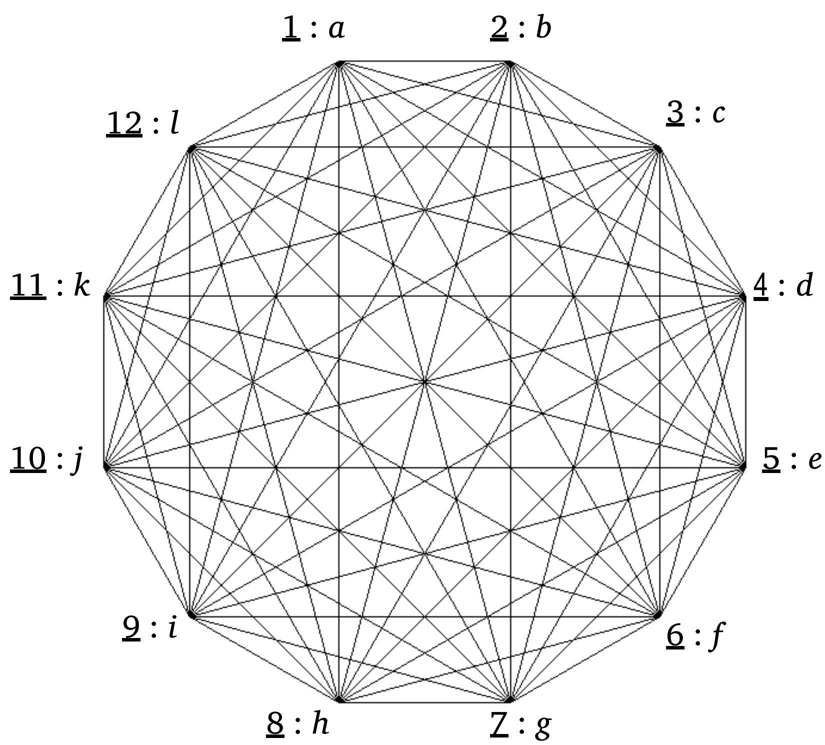


Figure 1. A maximally transparent paradigm with twelve cells

In the inflection of Comaltepec Chinantec verbs, there are (as in Figure 1) twelve different morphosyntactic property sets. In the remainder of the paper, we number these 1 through 12; the significance of these twelve numerals is given in Table 10.

TABLE 10. Abbreviations for the twelve property sets realized by Comaltepec Chinantec verb forms

Abbreviation	Property set	
1	1sg	Progressive
2	1pl	
3	2	
4	3	
5	1sg	Intentive
6	1pl	
7	2	
8	3	
9	1sg	Completive
10	1pl	
11	2	
12	3	

The question now arises whether there are any maximally transparent paradigms in Comaltepec Chinantec. That is, are there conjugation classes whose paradigms could be represented as in Figure 1? The answer is yes; in fact there are four such conjugations. One of these is Conjugation PDBB in Table 8, whose twelve alternative principal-part analyses are given in Table 11.

In Table 11, the cells in a lexeme's paradigm are given on the horizontal axis (where 1 through 12 represent the twelve morphosyntactic property sets corresponding to a verbal paradigm's twelve cells), and the different possible principal-part analyses are given on the vertical axis. Thus, each row represents a distinct principal-part analysis, and within a given row, the numeral ***n*** (any of the numerals ***1*** through ***12***) represents the morphosyntactic property set of the sole principal part in the principal-part analysis represented by that row. If a principal part ***P*** is listed in the column headed by a property set M in a given analysis, the realization of M is deducible from ***P*** in that analysis.

TABLE 11. The twelve alternative optimal principal-part analyses for Conjugation PDBB in Comaltepec Chinantec

	Principal part	Morphosyntactic property sets											
		1	2	3	4	5	6	7	8	9	10	11	12
Alternative analyses	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***
	2	***2***	***2***	***2***	***2***	***2***	***2***	***2***	***2***	***2***	***2***	***2***	***2***
	3	***3***	***3***	***3***	***3***	***3***	***3***	***3***	***3***	***3***	***3***	***3***	***3***
	4	***4***	***4***	***4***	***4***	***4***	***4***	***4***	***4***	***4***	***4***	***4***	***4***
	5	***5***	***5***	***5***	***5***	***5***	***5***	***5***	***5***	***5***	***5***	***5***	***5***
	6	***6***	***6***	***6***	***6***	***6***	***6***	***6***	***6***	***6***	***6***	***6***	***6***
	7	***7***	***7***	***7***	***7***	***7***	***7***	***7***	***7***	***7***	***7***	***7***	***7***
	8	***8***	***8***	***8***	***8***	***8***	***8***	***8***	***8***	***8***	***8***	***8***	***8***
	9	***9***	***9***	***9***	***9***	***9***	***9***	***9***	***9***	***9***	***9***	***9***	***9***
	10	***10***	***10***	***10***	***10***	***10***	***10***	***10***	***10***	***10***	***10***	***10***	***10***
	11	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***
	12	***12***	***12***	***12***	***12***	***12***	***12***	***12***	***12***	***12***	***12***	***12***	***12***

In Conjugation PDBB, any one of the cells in a lexeme's paradigm can be used as that lexeme's sole principal part--can be used, in other words, to deduce the realization of every one of the remaining eleven cells in the paradigm. This fact arises because each of the exponents of property sets 1 through 12 in Conjugation PDBB is unique to that conjugation. Table 12 lists the exponents of cells 1 through 12 in Conjugation PDBB; a comparison of these exponents with those given earlier in Tables 7-9 reveals that in each one of the twelve cells in the paradigm of a lexeme belonging to this conjugation, the exponence is absolutely distinctive of this conjugation.

TABLE 12. The exponence of property sets 1-12 in Conjugation PDBB in Comaltepec Chinantec

1	2	3	4	5	6	7	8	9	10	11	12	Example
DHL:′	DHL:′	DHL:′	DL:′	DHL:′	DHL:′	DHL:′	DL:′	DHL:′	DHL:′	DHL:′	DL:′	hmï^{L}gó:^{HL} 'deceive'

Only four conjugations have this property of maximal transparency in Comaltepec Chinantec; that is, most conjugations in this language deviate from maximal transparency. We now consider the consequences of this deviation.

IV. Deviations from maximal transparency in Comaltepec Chinantec verb paradigms

Although every cell is fully informative in the paradigm of a verb belonging to Conjugation PDBB (and can therefore potentially serve as that verb's sole principal part), this full informativeness is comparatively rare. In the paradigms of most verbs, many cells are to some extent uninformative; that is, they have either a limited capacity or no capacity to serve as optimal principal parts. The system of conjugations in Comaltepec Chinantec exhibits various means of compensating for this less-than-full informativeness of certain cells.

Consider first a case in which a particular cell in a verb's paradigm uniquely determines only one other cell. In the paradigm of a verb belonging to Conjugation P1A, the cell containing the realization of property set 1 (whose exponence is tone M with controlled stress) uniquely determines the cell containing the realization of property set 2 (which has the same exponence), since no matter what the conjugation, the implicative relation in (4) holds true in Comaltepec Chinantec.

(4) | Property set: 1
Exponence: M | ↔ | Property set: 2
Exponence: M |

Even so, the cell containing the realization of property set 1 doesn't uniquely determine any of the remaining ten cells in the paradigm of a verb belonging to Conjugation P1A. In order to deduce the latter cells, the cell associated with property set 12 must be appealed to--either by itself or in addition to the cell associated with property set 1, as in Table 13. (In this table and those below, if a pair ***P***, ***Q*** of principal parts is listed in the column headed by a property set M, the realization of M can only be deduced by simultaneous reference to ***P*** and ***Q***.)

TABLE 13. A representative optimal principal-part analysis for Conjugation P1A in Comaltepec Chinantec

Principal parts	Morphosyntactic property sets											
	1	2	3	4	5	6	7	8	9	10	11	12
1,12	***1***	***1***	***1,12***	***1,12***	***1,12***	***1,12***	***1,12***	***1,12***	***12***	***1,12***	***1,12***	***12***

As Table 13 shows, the uninformativeness of the cell containing the realization of property set 1 in Conjugation P1A makes it necessary to deduce certain cells by simultaneous reference to two principal parts. The cells containing the realizations of property sets 1 and 12 are not, however, the only viable set of principal parts for a verb this conjugation; another possibility is the set of cells containing the realizations of property sets 3 and 12, as in Table 14. Like the analysis in Table 13, the analysis in Table 14 requires two principal parts for this conjugation; although both analyses are optimal, the latter analysis might be preferred on the grounds that it makes lesser use of simultaneous reference to both principal parts in deducing the various nonprincipal parts.

TABLE 14. A representative optimal principal-part analysis for Conjugation P1A in Comaltepec Chinantec

Principal parts	Morphosyntactic property sets											
	1	2	3	4	5	6	7	8	9	10	11	12
3,12	***3***	***3***	***3***	***3***	***3***	***3***	***3***	***3***	***3***	***3***	***3,12***	***12***

As Table 14 shows, the number of nonprincipal parts that must be deduced by simultaneous reference to both principal parts can be minimized to one in Conjugation P1A. This sort of minimization isn't always possible, however. For instance, in the only optimal principal-part analysis for Conjugation P2C, seven of ten nonprincipal parts are deducible only by simultaneous reference to both principal parts; this analysis is given in Table 15.

TABLE 15. The sole optimal principal-part analysis for Conjugation P2C in Comaltepec Chinantec

Principal parts	Morphosyntactic property sets											
	1	2	3	4	5	6	7	8	9	10	11	12
11,12	***11,12***	***12***	***11,12***	***12***	***11,12***	***11,12***	***11,12***	***12***	***11,12***	***11,12***	***11***	***12***

Even so, the need to postulate two principal parts doesn't always entail a need for simultaneous reference to both of the principal parts in deducing one or another nonprincipal part. Consider, for example, Conjugation P1B, whose sole optimal principal-part analysis is given in Table 16. In the paradigm of a verb belonging to this conjugation, two principal-part specifications are necessary in order to deduce all of the remaining cells in the paradigm. In the only optimal analysis, the exponents of property sets 1 through 10 can all be deduced from the exponence of property set 11; the cell containing the realization of property set 11 is therefore one of the two principal parts of a verb belonging to this conjugation. The exponence of property set 12, however, cannot be deduced from that of property set 11, nor from that of any of the other property sets, and so must be independently specified. So here we have a conjugation that must have two principal parts, but no cell of which must be deduced by simultaneous reference to both principal parts.

TABLE 16. The sole optimal principal-part analysis for Conjugation P1B in Comaltepec Chinantec

Principal parts	Morphosyntactic property sets											
	1	2	3	4	5	6	7	8	9	10	11	12
11,12	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***12***

Another example of the same type is Conjugation P2F, which involves three principal parts. In the representative principal-part analysis proposed in Table 17, the principal parts of a verb belonging to Conjugation P2F are the realizations associated with property sets 1, 11, and 12.

TABLE 17. A representative optimal principal-part analysis for Conjugation P2F in Comaltepec Chinantec

Principal parts	Morphosyntactic property sets											
	1	2	3	4	5	6	7	8	9	10	11	12
1,11,12	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***11***	***12***

In Conjugation P3E, four principal parts are necessary. Table 18 represents the sole optimal principal-part analysis for this conjugation: The principal parts are the realizations of property sets 9, 10, 11, and 12.

TABLE 18. The sole optimal principal-part analysis for Conjugation P3E in Comaltepec Chinantec

Principal parts	Morphosyntactic property sets											
	1	2	3	4	5	6	7	8	9	10	11	12
9,10,11,12	***10***	***10***	***12***	***12***	***10***	***10***	***10***	***12***	***9***	***10***	***11***	***12***

In the deviations from maximal transparency that we have considered so far, the uninformativeness of certain realizations has forced us to postulate two or more principal parts; some but not all of these analyses involve deducing certain nonprincipal parts by simultaneous reference to more than one principal part. But uninformativeness needn't always lead to the postulation of more than one principal part. In some instances, it simply imposes limits on the range of alternative analyses.

For instance, a single principal part can be postulated for a verb belonging to Conjugation P16B, but there are only six cells in the paradigm of such a verb that can possibly serve as this sole principal part, namely the cells associated with property sets 3, 4, 7, 8, 11, and 12. The realizations in such a verb's paradigm can be deduced from any one of these cells but not from any other. Thus, a verb belonging to Conjugation P16B has the six alternative principal-part analyses represented in Table 19, but the realizations of property sets 1, 2, 5, 6, 9, and 10 in its paradigm are uninformative in any optimal principal-part analysis.

TABLE 19. The six optimal principal-part analyses for Conjugation P16B in Comaltepec Chinantec

	Principal part	Morphosyntactic property sets											
		1	2	3	4	5	6	7	8	9	10	11	12
Alternative analyses	***3***	***3***	***3***	***3***	***3***	***3***	***3***	***3***	***3***	***3***	***3***	***3***	***3***
	4	***4***	***4***	***4***	***4***	***4***	***4***	***4***	***4***	***4***	***4***	***4***	***4***
	7	***7***	***7***	***7***	***7***	***7***	***7***	***7***	***7***	***7***	***7***	***7***	***7***
	8	***8***	***8***	***8***	***8***	***8***	***8***	***8***	***8***	***8***	***8***	***8***	***8***
	11	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***
	12	***12***	***12***	***12***	***12***	***12***	***12***	***12***	***12***	***12***	***12***	***12***	***12***

Conjugation P12A exhibits an even more severe restriction on the range of alternative analyses. In the paradigm of a verb belonging to this conjugation, only one cell (namely the cell associated with property set 12) can serve as the verb's sole principal part; the other eleven cannot. That is, the remaining realizations in such a verb's paradigm can be deduced from the cell containing the realization of property set 12 but not from any other cell. Thus, Conjugation P12A has the sole optimal principal-part analysis in Table 20; in this respect, it contrasts starkly with Conjugation PDBB (Table 11), any one of whose twelve cells may serve as its sole principal part.

TABLE 20. The sole optimal principal-part analysis for Conjugation P12A in Comaltepec Chinantec

Principal part	Morphosyntactic property sets											
	1	2	3	4	5	6	7	8	9	10	11	12
12	***12***	***12***	***12***	***12***	***12***	***12***	***12***	***12***	***12***	***12***	***12***	***12***

The examples presented here show that the uninformativeness of one or more cells in a lexeme's paradigm may have either or both of two effects on the principal-part analysis of that lexeme: (i) it may necessitate the postulation of more than one principal part for that lexeme; and (ii) it may limit the number of alternative optimal principal-part analyses to which that lexeme is subject. These effects therefore imply two practical criteria for paradigmatic transparency:

(5) Two practical criteria for paradigmatic transparency
All else being equal,
a. fewer dynamic principal parts needed to deduce a lexeme's paradigm in an optimal analysis implies greater transparency of that paradigm;
b. more alternative optimal principal-part analyses of a lexeme's paradigm implies greater transparency of that paradigm.

The transparency of Comaltepec Chinantec paradigms varies widely according to both of the criteria in (5), as we now show. Consider first Table 21, which relates to criterion (5a). As

Table 21 shows, many of the conjugations involve paradigms that can be deduced from a single dynamic principal part; even more, however, have paradigms requiring two dynamic principal parts, and some require as many as three or even four dynamic principal parts. Thus, the successive rows in Table 21 represent decreasing levels of transparency according to criterion (5a).

TABLE 21. Numbers of dynamic principal parts for Comaltepec Chinantec conjugation classes

Comaltepec Chinantic conjugation classes	Number of dynamic principal parts needed to identify a particular inflection class
P3A, P10, P11, P12A, P14A, P15A, P15B, P16A, P16B, P16C, PCMA, PCMB, PCMC, PDBA, PDBB, PDBC, PDBD, PDCA, PDCB, PDCC	1
P1A, P1B, P1D, P1E, P2A, P2B, P2C, P2D, P2E, P2G, P3C, P3F, P3H, P3I, P3J, P3K, P3L, P4A, P4B, P4C, P5A, P5B, P6A, P6B, P6C, P7A, P7B, P7C, P7D, P7E, P7F, P8A, P8B, P9A, P9B, P12B, P12C, P13A, P13B, P14B	2
P1C, P2F, P3D, P3G, P9C	3
P3B, P3E	4

Conjugations whose optimal analysis requires the same number of principal parts may nevertheless vary in the extent to which they require simultaneous reference to more than one principal part in deducing a cell's realization. Table 22 shows the average number of principal parts needed to deduce a cell's realization in each conjugation in Comaltepec Chinantec. The conjugation classes in rows A through D house verbs whose each of whose realizations can always be deduced by reference to a single principal part; those in the succeeding rows house verbs whose realizations must--to a progressively greater degree--be deduced through simultaneous reference to more than one principal part.

TABLE 22. Average number of principal parts needed to identify a cell in Comaltepec Chinantec

	Comaltepec Chinantec conjugation classes	Number of dynamic principal parts needed to deduce a lexeme's paradigm	Average number of principal parts needed to deduce a cell in a lexeme's paradigm
A.	P3A, P10, P11, P12A, P14A, P15A, P15B, P16A, P16B, P16C, PCMA, PCMB, PCMC, PDBA, PDBB, PDBC, PDBD, PDCA, PDCB, PDCC	1	1.00
B.	P1B, P1D, P1E, P3H, P3I, P3J, P3K, P3L, P4A, P4B, P4C, P6A, P6B, P6C, P7A, P7B, P7C, P7D, P7E, P7F, P8A, P8B, P9B, P13A	2	
C.	P1C, P2F, P3D, P9C	3	
D.	P3B, P3E	4	
E.	P1A, P2A, P2B, P2D, P12B, P12C, P13B	2	1.08
F.	P3F, P9A	2	1.25
G.	P3G	3	
H.	P5B	2	1.33
I.	P3C, P14B	2	1.42
J.	P2C, P2E	2	1.58
K.	P5A	2	1.67
L.	P2G	2	1.75

Table 23 relates to criterion (5b). Here the different conjugations are arranged according to the number of optimal principal-part analyses that they afford. The conjugation allowing the largest number of optimal principal-part analyses is P9C, which allows twenty optimal analyses; but succeeding rows show conjugations allowing fewer analyses, with the bottom rows showing conjugations allowing only a single optimal principal-part analysis. Thus, by criterion (5b), Table 23 lists conjugation classes in decreasing order of paradigmatic transparency.

TABLE 23. Numbers of optimal principal-part analyses for Comaltepec Chinantec conjugations

Conjugation	Number of principal parts	Number of optimal principal-part analyses
P9C	3	20
P12C	2	17
P14B	2	16
P3B	4	
PDBB, PDBD, PDCB, PDCC	1	12
P11	1	11
P2A, P6A	2	
P6B	2	10
PCMA	1	9
P7A, P7C, P7F, P12B	2	
P6C, P13B	2	8
P15A	1	7
P1A, P5B, P7D, P8A, P9B, P13A	2	
P1C, P2F	3	
P16A, P16B, P16C, PDCA	1	6
P1E, P2B, P7B, P7E, P8B, P9A	2	
P15B	1	5
P2D	2	
P3C, P4A, P4C	2	4
PCMB, PCMC, PDBA, PDBC	1	3
P4B	2	2
P3A, P10, P12A, P14A	1	1
P1B, P1D, P2C, P2E, P2G, P3F, P3H, P3I, P3J, P3K, P3L, P5A	2	
P3D, P3G	3	
P3E	4	

The application of criterion (5b) is complicated, however, by the fact that a paradigm is open to more alternative principal-part analyses the more principal parts it has. Thus, (5b) should be interpreted as meaning that the larger the number of principal-part analyses a conjugation has, the more transparent its paradigms are in comparison with those of other conjugations having the same number of principal parts. Where lexeme L has k principal parts and n is the number of morphosyntactic property sets for which L inflects, the largest possible number of optimal principal-part analyses for L is the binomial coefficient of n and k, i.e. $n!/(k!(n-k)!)$. The maximum possible number of optimal principal-part analyses for a Comaltepec Chinantec verb varies according to the number of principal parts it has, as in Table 24. Although the paradigm of a lexeme belonging to Conjugation P9C has the twenty alternative optimal principal-part analyses in Table 25, this paradigm is not all that transparent, since it has three principal parts, and is therefore far below the ceiling of 220 optimal analyses that a lexeme with three principal parts could imaginably have.

TABLE 24. Maximum possible number of optimal principal-part analyses for Comaltepec Chinantec verbs

Number (k) of principal parts	Maximum possible number $12!/(k!(12-k)!)$ of optimal principal-part analyses
1	12
2	66
3	220
4	495

TABLE 25. The twenty alternative optimal principal-part analyses for Conjugation P9C in Comaltepec Chinantec

	Principal parts	Morphosyntactic property sets											
		1	2	3	4	5	6	7	8	9	10	11	12
Alternative analyses	***1,4,11***	***1***	***1***	***1***	***4***	***1***	***1***	***1***	***4***	***1***	***1***	***11***	***4***
	1,8,11	***1***	***1***	***1***	***1,8***	***1***	***1***	***1***	***8***	***1***	***1***	***11***	***1,8***
	1,11,12	***1***	***1***	***1***	***12***	***1***	***1***	***1***	***12***	***1***	***1***	***11***	***12***
	2,4,11	***2***	***2***	***2***	***4***	***2***	***2***	***2***	***4***	***2***	***2***	***11***	***4***
	2,8,11	***2***	***2***	***2***	***2,8***	***2***	***2***	***2***	***8***	***2***	***2***	***11***	***2,8***
	2,11,12	***2***	***2***	***2***	***12***	***2***	***2***	***2***	***12***	***2***	***2***	***11***	***12***
	3,4,11	***3***	***3***	***3***	***4***	***3***	***3***	***3***	***4***	***3***	***3***	***11***	***4***
	3,8,11	***3***	***3***	***3***	***3,8***	***3***	***3***	***3***	***8***	***3***	***3***	***11***	***3,8***
	3,11,12	***3***	***3***	***3***	***12***	***3***	***3***	***3***	***12***	***3***	***3***	***11***	***12***
	4,5,11	***4,5***	***4,5***	***4,5***	***4***	***5***	***4,5***	***4,5***	***4***	***4,5***	***4***	***11***	***4***
	4,6,11	***6***	***6***	***6***	***4***	***6***	***6***	***6***	***4***	***6***	***4***	***11***	***4***
	4,7,11	***7***	***7***	***7***	***4***	***7***	***7***	***7***	***4***	***7***	***4***	***11***	***4***
	4,9,11	***9***	***9***	***9***	***4***	***9***	***9***	***9***	***4***	***9***	***4***	***11***	***4***
	5,11,12	***5,12***	***5,12***	***5,12***	***12***	***5***	***5,12***	***5,12***	***12***	***5,12***	***12***	***11***	***12***
	6,8,11	***6***	***6***	***6***	***6,8***	***6***	***6***	***6***	***8***	***6***	***6***	***11***	***6,8***
	6,11,12	***6***	***6***	***6***	***12***	***6***	***6***	***6***	***12***	***6***	***6***	***11***	***12***
	7,8,11	***7***	***7***	***7***	***7,8***	***7***	***7***	***7***	***8***	***7***	***7***	***11***	***7,8***
	7,11,12	***7***	***7***	***7***	***12***	***7***	***7***	***7***	***12***	***7***	***7***	***11***	***12***
	8,9,11	***9***	***9***	***9***	***8,9***	***9***	***9***	***9***	***8***	***9***	***9***	***11***	***8,9***
	9,11,12	***9***	***9***	***9***	***12***	***9***	***9***	***9***	***12***	***9***	***9***	***11***	***12***

By the criteria in (5), Comaltepec Chinantec verb conjugations exhibit widely varying degrees of paradigmatic transparency. At the high extreme, that of total paradigmatic transparency, are the conjugations in (6a): lexemes in these conjugations exhibit only a single principal part and allow the maximum number of alternative optimal principal-part analyses. At the opposite extreme is the conjugation in (6b): lexemes in Conjugation P3E have four principal parts and allow only a single optimal principal-part analysis. Between these extremes, other lexemes exhibit a range of intermediate degrees of paradigmatic transparency.

(6) Extreme degrees of paradigmatic transparency in Comaltepec Chinantec
a. High: PDBB, PDBD, PDCB, PDCC
b. Low: P3E

V. A measure of paradigmatic transparency

Although the practical criteria in (5) are useful for distinguishing degrees of paradigmatic transparency, we would like to give more explicit content to the notion of paradigmatic transparency than these criteria allow. We therefore propose a precise measure of paradigmatic transparency; we call this measure PARADIGM PREDICTABILITY. The fundamental idea underlying this proposed measure is that where (i) M is the set of morphosyntactic property sets associated with the cells in the paradigm P_L of some lexeme L and (ii) M' is the set $\{ N : N \subseteq M$ and the exponence in P_L of the morphosyntactic property sets belonging to N suffices to determine the exponence in P_L of every morphosyntactic property set belonging to $M\}$, L's paradigm predictability PP_L is calculated as in (7). In effect, this measure calculates the fraction of the members of M's power set $\mathcal{P}(M)$ that are viable (though not necessarily optimal) sets of dynamic principal parts for L.

(7) $$\text{PP}_L = \frac{|M'|}{|\mathcal{P}(M)|}$$

We refine this measure of paradigm predictability in two ways. First, the set M sometimes contains multiple morphosyntactic property sets whose exponence is the same across all inflection classes. We propose to eliminate all but one of these sets from M for purposes of calculating paradigm predictability. To understand why, consider the two hypothetical inflection-class systems in (8), in which I through IV represent inflection classes; s_1 through s_3 represent morphosyntactic property sets; and a through c represent inflectional exponents.

(8) System (8a)

	s_1	s_2	s_3
I	a	b	b
II	a	c	c
III	b	b	b
IV	c	c	c

System (8b)

	s_1	s_2
I	a	b
II	a	c
III	b	b
IV	c	c

If paradigm predictability is calculated as in (7), then lexemes belonging to inflection class I in system (8a) have greater paradigm predictability than lexemes belonging to inflection class I in system (8b): the former have a predictability of $\frac{3}{8}$ ($M = \{s_1, s_2, s_3\}$, M' has three members $\{s_1, s_2\}$, $\{s_1, s_3\}$, $\{s_1, s_2, s_3\}$, and $\mathcal{P}(M)$ has eight), while the latter have a predictability of ¼ ($M = \{s_1, s_2\}$, M' has one member $\{s_1, s_2\}$, and $\mathcal{P}(M)$ has four). We prefer to think of lexemes in these systems as having the same predictability, namely ¼. To accommodate this preference, we let M_- be a maximal subset of M such that no two of members of M_- are identical in their exponence across all conjugations. (If the property sets in M are ordered, M_- is the result of removing from M every property set s_n such that for some s_m in M, (a) $s_m < s_n$ and (b) s_m and s_n have the same exponence across all conjugations.) Accordingly, M'_- is the set $\{ N : N \subseteq M_-$ and the exponence in P_L of the morphosyntactic property sets belonging to N suffices to determine the exponence in P_L of every morphosyntactic property set belonging to $M_- \}$, and L's paradigm predictability PP_L is calculated as in (9) rather than as in (7).

(9) $$\text{PP}_L = \frac{|\,M'_{-}\,|}{|\mathcal{P}(M_{-})|}$$

The second refinement in the calculation of paradigm predictability stems from the fact that where N is a large subset of M_{-}, the exponence in P_L of the morphosyntactic property sets belonging to N is generally very likely to determine the exponence in P_L of every morphosyntactic property set belonging to M_{-}. That is, the subsets of M_{-} that are best for distinguishing degrees of paradigm predictability tend to be the smaller subsets of M_{-}. We have therefore chosen--somewhat arbitrarily--to base our calculation of paradigm predictability on subsets of M_{-} having no more than seven members. For any set S of sets, we use ${}_{\leq 7}S$ to represent the largest subset of S such that for every $s \in {}_{\leq 7}S$, $|s| \leq 7$. We accordingly calculate L's paradigm predictability PP_L as in (10) rather than as in (9).

(10) $$\text{PP}_L = \frac{|{}_{\leq 7}M'_{-}\,|}{|{}_{\leq 7}\mathcal{P}(M_{-})|}$$

This measure of paradigm predictability accounts for both of the practical criteria in (5). Consider first criterion (5a), which associates a smaller number of dynamic principal parts with greater paradigmatic transparency. By this criterion, Conjugation P3A exhibits greater paradigmatic transparency than Conjugation P3J, since the only optimal analysis of Conjugation P3A involves a single principal part (Table 26), while the only optimal analysis for Conjugation P3J involves two principal parts (Table 27). This difference reflects a measurable contrast in the paradigm predictability of the two conjugations: the predictability of a member of Conjugation P3A is 0.450, while that of a member of P3J is merely 0.193.

TABLE 26. The sole optimal principal-part analysis for Conjugation P3A in Comaltepec Chinantec

Principal part	Morphosyntactic property sets											
	1	2	3	4	5	6	7	8	9	10	11	12
11	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***	***11***

TABLE 27. The sole optimal principal-part analysis for Conjugation P3J in Comaltepec Chinantec

Principal part	Morphosyntactic property sets											
	1	2	3	4	5	6	7	8	9	10	11	12
9,11	***9***	***9***	***9***	***9***	***9***	***9***	***9***	***9***	***9***	***9***	***11***	***9***

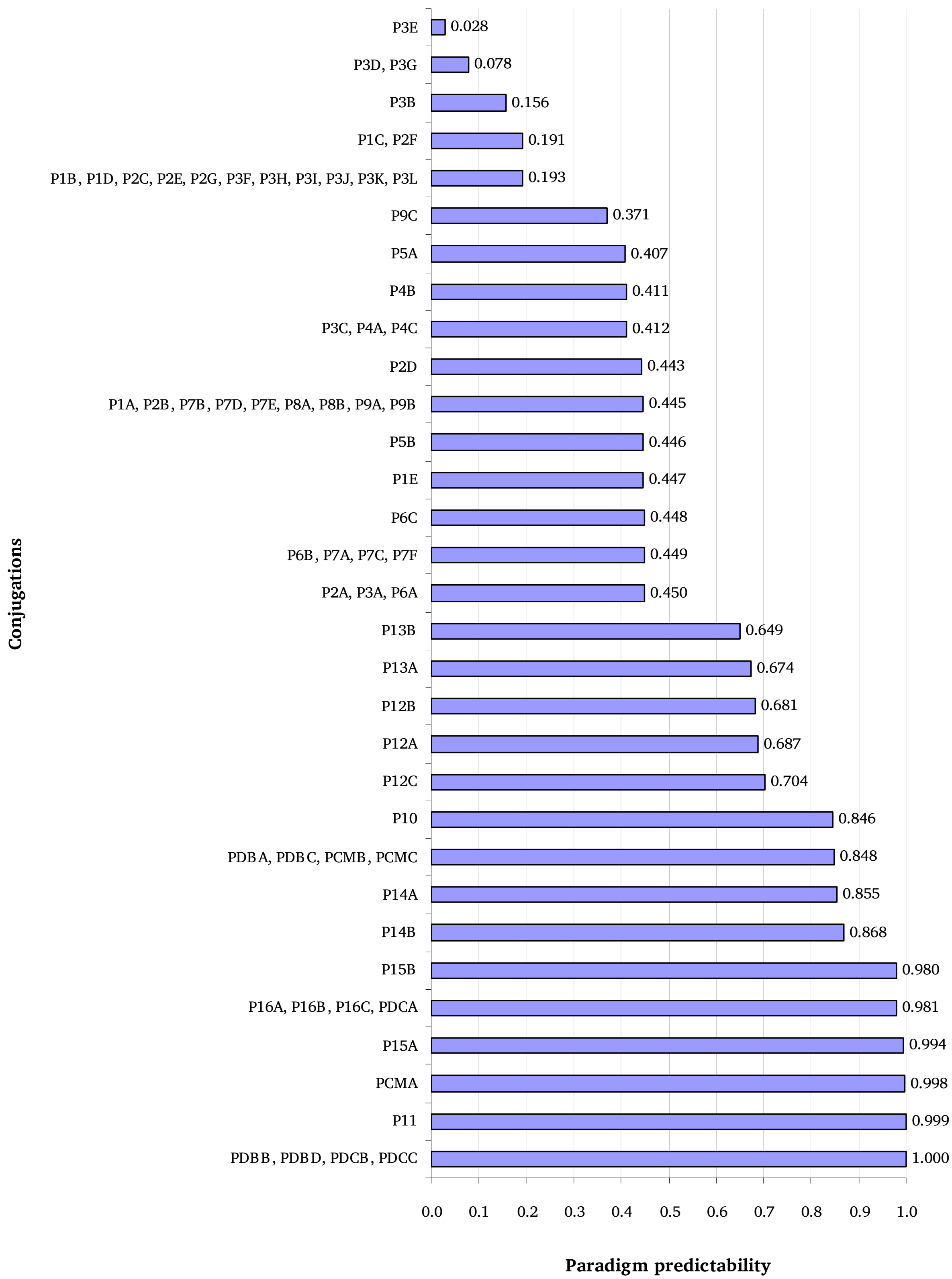
Consider now criterion (5b), which associates greater paradigmatic transparency with a greater number of alternative inflection-class analyses. By this criterion, Conjugation PDBB exhibits greater paradigmatic transparency than Conjugation P3A, since the former allows the twelve optimal principal-part analyses in Table 11, while the latter only allows the single optimal principal-part analysis in Table 26. This difference reflects a measurable contrast in the paradigm predictability of these two conjugations: the predictability of a member of Conjugation PDBB is 1.000, while the predictability of a member of P3A is merely 0.450.

Applying the measure of paradigm predictability to all of the conjugations in Comaltepec Chinantec yields the results in Table 28 [**alternative version on next page**]. Close inspection reveals four points at which the gradient of paradigm predictability in Table 28 breaks sharply; these breaks are indicated by the lines separating parts A through E of the table. We believe that these breaks are best understood with respect to a second measure pertinent to paradigmatic transparency. CELL PREDICTABILITY measures the predictability of a cell's realization from the realization of the other cells in its paradigm (whether or not these are optimal principal parts).

TABLE 28. Paradigm predictability across conjugations in Comaltepec Chinantec

	Conjugations	Paradigm predictability
A.	PDBB, PDBD, PDCB, PDCC	1.000
	P11	0.999
	PCMA	0.998
	P15A	0.994
	P16A, P16B, P16C, PDCA	0.981
	P15B	0.980
	P14B	0.868
	P14A	0.855
	PDBA, PDBC, PCMB, PCMC	0.848
	P10	0.846
	P12C	0.704
	P12A	0.687
	P12B	0.681
	P13A	0.674
	P13B	0.649
B.	P2A, P3A, P6A	0.450
	P6B, P7A, P7C, P7F	0.449
	P6C	0.448
	P1E	0.447
	P5B	0.446
	P1A, P2B, P7B, P7D, P7E, P8A, P8B, P9A, P9B	0.445
	P2D	0.443
	P3C, P4A, P4C	0.412
	P4B	0.411
	P5A	0.407
	P9C	0.371
C.	P1B, P1D, P2C, P2E, P2G, P3F, P3H, P3I, P3J, P3K, P3L	0.193
	P1C, P2F	0.191
	P3B	0.156
D.	P3D, P3G	0.078
E.	P3E	0.028

Table 28. Paradigm predictability across conjugations in Comaltepec Chinantec



The fundamental idea underlying our proposed measure of cell predictability is that where (i) M is the set of morphosyntactic property sets associated with the cells in the paradigm P_L of some lexeme L and (ii) M_s is the set { $N : N \subseteq M_{-}$ and the exponence in P_L of the morphosyntactic property sets belonging to N suffice to determine the exponence in P_L of the property set s }, the cell predictability $\mathrm{CP}_{s,L}$ of s in P_L is calculated as in (11).

(11) $$\mathrm{CP}_{s,L} = \frac{|{}_{\leq 7}M_s|}{|{}_{\leq 7}\mathcal{P}(M_{-})|}$$

Here, too, a refinement must be made. Because the exponence of property set s always suffices to determine itself, the inclusion of s in M_s invariably enhances cell predictability, thereby diminishing distinctions in cell predictability. We therefore exclude s from M_s in calculating cell predictability. For any collection C of sets, we use $C_{[s]}$ to represent the largest subset of C such that no member of $C_{[s]}$ contains s. Cell predictability is then calculated as in (12).

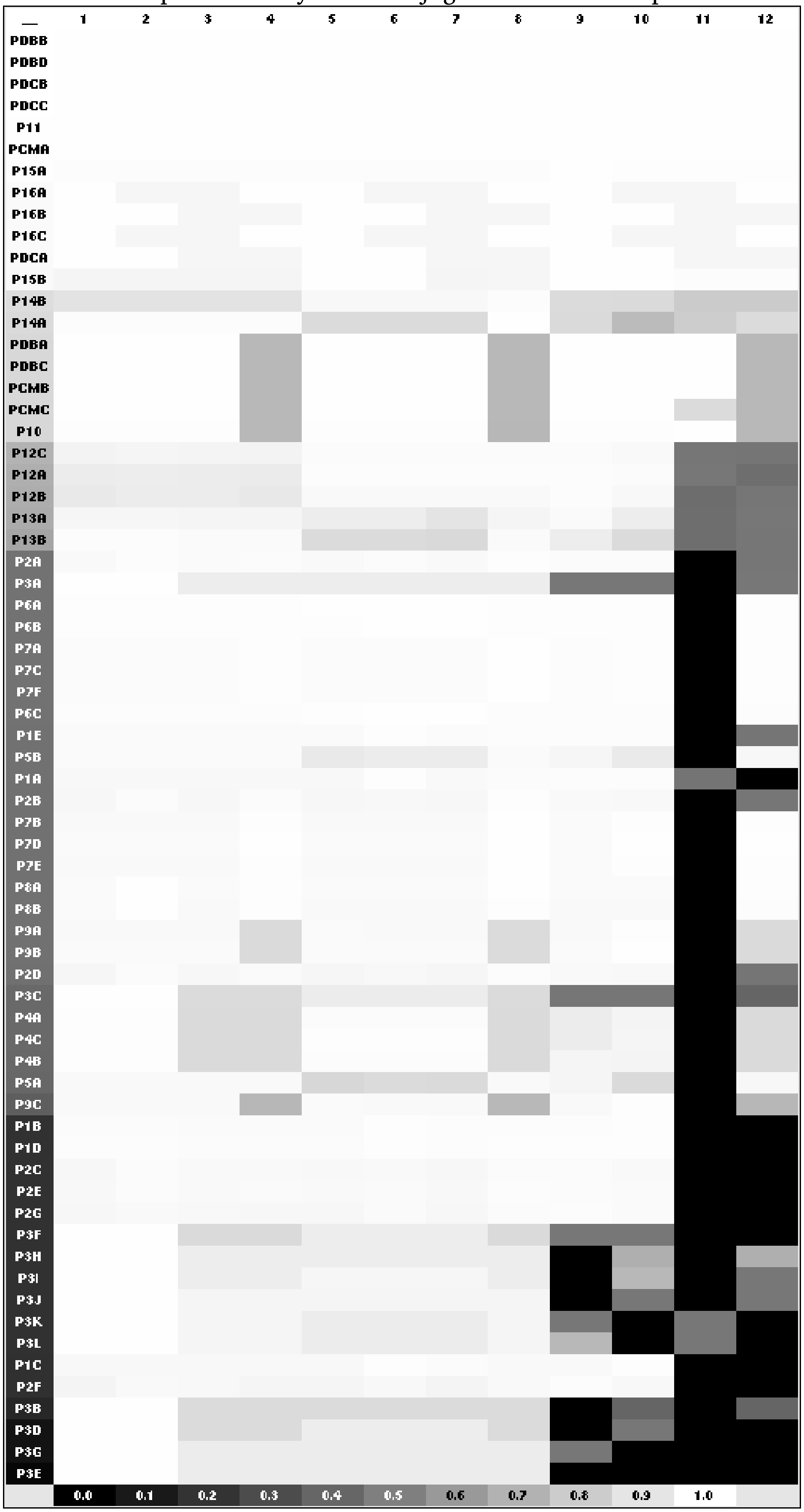
(12) $$\mathrm{CP}_{s,L} = \frac{|{}_{\leq 7}M_{[s]}|}{|{}_{\leq 7}\mathcal{P}(M_{-})_{[s]}|}$$

By this measure, the cells in the paradigms of Comaltepec Chinantec verbs have the cell predictability in Table 29; average cell predictability and paradigm predictability are listed in the table's rightmost two columns. The measure of cell predictability shows that the major breaks in the gradient of paradigm predictability correspond to the appearance of an unpredictable cell (i.e. one whose cell predictability is 0). The conjugations in part A of Table 28 have no unpredictable cells; those in part B have one unpredictable cell; those in part C have two unpredictable cells; and so on. (The cell predictability measures of unpredictable cells are shaded in Table 29.) Thus, the cell predictability measure reveals an important fact about paradigmatic transparency: Cell unpredictability degrades paradigm predictability. Inevitably, an unpredictable cell must be a principal part. [**An alternative version of Table 29 is given two pages hence. In this alternative version, morphosyntactic property sets are listed on the horizontal axis, conjugations are listed on the vertical axis (in order of decreasing paradigm predictability), and the lightness of a cell's shading represents its degree of cell predictability.**]

TABLE 29. Cell predictability in all conjugations in Comaltepec Chinantec

Conj	1	2	3	4	5	6	7	8	9	10	11	12	Avg cell predictability	Paradigm predictability
PDBB, PDBD, PDCB, PDCC	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	1.000
P11	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999
PCMA	0.999	0.999	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.998	0.997	0.998	0.998
P15A	0.989	0.989	0.989	0.989	0.989	0.989	0.989	0.991	0.998	0.995	0.993	0.994	0.991	0.994
P16A, P16C	0.999	0.965	0.965	0.999	0.999	0.965	0.965	0.999	0.999	0.965	0.965	0.999	0.982	0.981
P16B, PDCA	0.999	0.999	0.965	0.965	0.999	0.999	0.965	0.965	0.999	0.999	0.965	0.965	0.982	0.981
P15B	0.964	0.964	0.964	0.964	0.997	0.997	0.964	0.965	0.999	0.997	0.989	0.990	0.979	0.980
P14B	0.892	0.892	0.892	0.892	0.974	0.974	0.974	0.991	0.859	0.857	0.798	0.798	0.900	0.868
P14A	0.990	0.990	0.990	0.990	0.860	0.860	0.860	0.998	0.858	0.737	0.807	0.859	0.900	0.855
PDBA, PDBC, PCMB	0.999	0.999	0.999	0.724	0.999	0.999	0.999	0.724	0.999	0.999	0.999	0.724	0.930	0.848
PCMC	0.997	0.997	0.997	0.724	0.998	0.997	0.997	0.724	0.997	0.998	0.860	0.724	0.917	0.848
P10	0.996	0.996	0.996	0.724	0.996	0.996	0.996	0.720	0.996	0.996	0.998	0.724	0.927	0.846
P12C	0.956	0.963	0.960	0.954	0.987	0.987	0.987	0.987	0.987	0.980	0.466	0.461	0.890	0.704
P12A	0.926	0.930	0.928	0.925	0.991	0.991	0.991	0.991	0.989	0.986	0.467	0.432	0.879	0.687
P12B	0.914	0.928	0.927	0.913	0.979	0.979	0.979	0.979	0.989	0.973	0.428	0.463	0.871	0.681
P13A	0.965	0.965	0.961	0.961	0.930	0.930	0.896	0.961	0.982	0.930	0.432	0.467	0.865	0.674
P13B	0.991	0.991	0.983	0.983	0.860	0.860	0.852	0.983	0.930	0.860	0.432	0.463	0.849	0.649
P2A	0.979	0.990	0.982	0.986	0.980	0.986	0.979	0.993	0.988	0.985	0.000	0.466	0.859	0.450
P3A	0.999	0.999	0.930	0.930	0.930	0.930	0.930	0.930	0.467	0.467	0.000	0.467	0.748	0.450
P6A	0.994	0.994	0.994	0.994	0.997	0.998	0.998	0.994	0.994	0.994	0.000	0.995	0.912	0.450
P6B	0.994	0.994	0.994	0.994	0.996	0.998	0.997	0.994	0.994	0.994	0.000	0.994	0.912	0.449
P7A	0.988	0.988	0.988	0.995	0.988	0.988	0.988	0.998	0.990	0.996	0.000	0.995	0.908	0.449
P7C	0.988	0.988	0.988	0.995	0.988	0.988	0.988	0.997	0.990	0.996	0.000	0.995	0.908	0.449
P7F	0.988	0.988	0.988	0.995	0.988	0.988	0.988	0.998	0.991	0.996	0.000	0.995	0.908	0.449
P6C	0.991	0.991	0.991	0.991	0.995	0.998	0.998	0.991	0.991	0.991	0.000	0.991	0.910	0.448
P1E	0.983	0.983	0.981	0.981	0.981	0.994	0.987	0.989	0.989	0.991	0.000	0.461	0.860	0.447
P5B	0.982	0.982	0.982	0.982	0.917	0.929	0.927	0.982	0.965	0.921	0.000	0.970	0.878	0.446
P1A	0.976	0.976	0.974	0.974	0.974	0.993	0.980	0.988	0.989	0.992	0.458	0.000	0.856	0.445
P2B	0.970	0.988	0.972	0.985	0.971	0.976	0.970	0.993	0.980	0.976	0.000	0.465	0.854	0.445
P7B	0.980	0.980	0.980	0.995	0.980	0.980	0.980	0.997	0.982	0.996	0.000	0.995	0.904	0.445
P7D	0.981	0.981	0.981	0.997	0.981	0.981	0.981	0.998	0.982	0.998	0.000	0.997	0.905	0.445
P7E	0.980	0.980	0.980	0.994	0.980	0.980	0.980	0.997	0.982	0.996	0.000	0.994	0.904	0.445
P8A	0.982	0.998	0.981	0.996	0.981	0.981	0.981	0.998	0.981	0.981	0.000	0.993	0.905	0.445
P8B	0.982	0.998	0.980	0.994	0.980	0.980	0.980	0.996	0.980	0.980	0.000	0.992	0.904	0.445
P9A	0.980	0.980	0.980	0.856	0.982	0.980	0.980	0.859	0.980	0.996	0.000	0.856	0.869	0.445
P9B	0.981	0.981	0.981	0.858	0.982	0.981	0.981	0.860	0.981	0.998	0.000	0.858	0.870	0.445
P2D	0.967	0.988	0.972	0.981	0.968	0.974	0.967	0.989	0.980	0.973	0.000	0.461	0.852	0.443
P3C	0.998	0.998	0.860	0.860	0.929	0.929	0.929	0.860	0.466	0.466	0.000	0.397	0.724	0.412
P4A	0.996	0.996	0.857	0.858	0.988	0.988	0.988	0.858	0.928	0.958	0.000	0.858	0.856	0.412
P4C	0.996	0.996	0.857	0.858	0.993	0.993	0.993	0.858	0.928	0.962	0.000	0.858	0.858	0.412
P4B	0.994	0.994	0.855	0.858	0.991	0.991	0.991	0.856	0.961	0.960	0.000	0.858	0.859	0.411
P5A	0.980	0.980	0.980	0.980	0.844	0.860	0.858	0.980	0.963	0.856	0.000	0.972	0.854	0.407
P9C	0.980	0.980	0.980	0.721	0.982	0.980	0.980	0.724	0.980	0.996	0.000	0.721	0.835	0.371
P1B	0.985	0.985	0.983	0.983	0.983	0.996	0.989	0.989	0.989	0.994	0.000	0.000	0.823	0.193
P1D	0.989	0.989	0.987	0.987	0.987	0.996	0.990	0.993	0.993	0.994	0.000	0.000	0.826	0.193
P2C	0.972	0.986	0.979	0.980	0.975	0.980	0.972	0.988	0.986	0.979	0.000	0.000	0.816	0.193
P2E	0.976	0.987	0.979	0.983	0.979	0.983	0.976	0.992	0.986	0.982	0.000	0.000	0.819	0.193
P2G	0.969	0.978	0.975	0.971	0.971	0.982	0.969	0.988	0.991	0.981	0.000	0.000	0.814	0.193
P3F	0.998	0.998	0.858	0.858	0.930	0.930	0.930	0.858	0.467	0.467	0.000	0.000	0.691	0.193
P3H	0.999	0.999	0.930	0.930	0.930	0.930	0.930	0.930	0.000	0.688	0.000	0.688	0.746	0.193
P3I	0.999	0.999	0.930	0.930	0.965	0.965	0.965	0.930	0.000	0.724	0.000	0.467	0.739	0.193
P3J	0.999	0.999	0.964	0.964	0.964	0.964	0.964	0.964	0.000	0.467	0.000	0.467	0.726	0.193
P3K	0.998	0.998	0.964	0.964	0.929	0.929	0.929	0.964	0.467	0.000	0.467	0.000	0.718	0.193
P3L	0.997	0.997	0.963	0.963	0.929	0.929	0.929	0.963	0.724	0.000	0.467	0.000	0.738	0.193
P1C	0.976	0.976	0.974	0.974	0.974	0.994	0.988	0.980	0.980	0.993	0.000	0.000	0.817	0.191
P2F	0.960	0.977	0.974	0.963	0.963	0.974	0.960	0.980	0.990	0.973	0.000	0.000	0.810	0.191
P3B	0.999	0.999	0.860	0.860	0.860	0.860	0.860	0.860	0.000	0.397	0.000	0.397	0.662	0.156
P3D	0.999	0.999	0.860	0.860	0.930	0.930	0.930	0.860	0.000	0.467	0.000	0.000	0.653	0.078
P3G	0.997	0.997	0.928	0.928	0.929	0.929	0.929	0.928	0.467	0.000	0.000	0.000	0.669	0.078
P3E	0.998	0.998	0.929	0.929	0.929	0.929	0.929	0.929	0.000	0.000	0.000	0.000	0.631	0.028

TABLE 29. Cell predictability in all conjugations in Comaltepec Chinantec



VI. Paradigmatic transparency and the No-Blur Principle

There can be no doubt that paradigmatic transparency helps the language user, both in the domain of language learning and in that of lexical storage. Nevertheless, the facts presented above raise doubts about the extent to which paradigmatic transparency is necessary in human language. In particular, they cast doubt on the No-Blur Principle, a hypothesis which alleges that an extremely high value is placed on avoiding paradigmatic opacity.

Cameron-Faulkner & Carstairs-McCarthy (2000:816) formulate the No-Blur Principle (NBP) as in (13).

(13) The No-Blur Principle
Among the rival affixes for any inflectional cell, at most one affix may fail to be a class-identifier, in which case that one affix is the class-default for that cell.

This principle entails that all of the affixal exponents for the inflection of lexemes belonging to a particular category fall into two classes: class-identifiers and class-defaults.

(14) a. A CLASS-IDENTIFYING affix is one that is peculiar to one inflection class, so that it can be taken as diagnostic of membership in that class.
b. A CLASS-DEFAULT affix is one that is shared by more than one inflection class, and all of whose rivals (if any) are class-identifiers.
(Cameron-Faulkner & Carstairs-McCarthy 2000:815)

If all affixes have to be either class-identifiers or class-defaults (as the NBP assumes), then any lexeme that ever inflects by means of a class-identifier needs only one principal part: the word containing that class-identifier suffices to indicate which inflection class the lexeme belongs to. The only situation in which this won't hold true is one in which none of the words in a lexeme's paradigm contains a class-identifier; in that case, the lexeme's words must inflect entirely by means of class-default affixes. But if at most one affix per cell may fail to be a class-identifier, then there can only be one inflection class whose inflection is based entirely on class-default affixes. This, therefore, is the only inflection class whose members could have more than one principal part. That is, the NBP has the entailment in (15):

(15) Of all the inflection classes for lexemes of a given syntactic category, at most one requires more than one principal part.

The NBP is apparently disconfirmed by Comaltepec Chinantec; but Cameron-Faulkner & Carstairs-McCarthy assume that the NBP only relates to affixal exponence, and in Comaltepec Chinantec, conjugation classes are distinguished by non-affixal morphology. What about affixal exponence?

The affixal inflection of Fur (Nilo-Saharan; Sudan) decisively disconfirms the NBP. In Fur, different conjugations are distinguished by the tonality of the verb root and by suffixation, as in Table 30.

TABLE 30. Affixal and nonaffixal exponents of Fur conjugations

Conjugation	Examples	Nonthird person			Third person								
					Singular			Plural					
								Nonhuman			Human		
		Subj	Perf	Pres	Subj	Perf	Pres	Subj	Perf	Pres	Subj	Perf	Pres
I,1a	buuN ‘descend’	LH-o	LH-ò	LH-èl	HH-o	HH-ò	HH-èl	HH-òl	HH-ùl	HH-èl-à/-ì	LH-òl	LH-ùl	LH-èl-à/-ì
I,1b	jaan ‘wait’	LH-o	LH-ò	LF-Ø	HH-o	HH-ò	HF-Ø	HH-òl	HH-ùl	HH-è	LH-òl	LH-ùl	LH-è
I,1c	irt ‘shake’	LH-o	LH-ò	LH-ì	HH-o	HH-ò	HH-ì	HH-òl	HH-ùl	HH-è	LH-òl	LH-ùl	LH-è
I,2a	tall ‘chew’	HH-ò	HH-o	HH-èl	LL-o	LL-ò	LL-èl	LL-òl	LL-ùl	LL-èl-à/-ì	HH-òl	HH-ùl	HH-èl-à/-ì
I,2b	fuul ‘spin’	HH-ò	HH-o	HF-Ø	LL-o	LL-ò	LL-Ø	LL-òl	LL-ùl	LL-è	HH-òl	HH-ùl	HH-è
I,2c	kir ‘cook’	HH-ò	HH-o	HH-ì	LL-o	LL-ò	LL-ì	LL-òl	LL-ùl	LL-è	HH-òl	HH-ùl	HH-è
II,1a	rii ‘snatch’	LH-i	LH-i	LH-itì	HH-i	HH-i	HH-itì	HH-i-A(l)	HH-i-è	HH-iti-A(l)	LH-i-A(l)	LH-i-è	LH-iti-A(l)
II,1b	tiir ‘meet’	LH-i	LH-i	LF-Ø	HH-i	HH-i	HF-Ø	HH-i-A(l)	HH-i-è	HH-è	LH-i-A(l)	LH-i-è	LH-è
II,2a	*faul ‘open’	HH-ì	HH-ì	HH-itì	LL-i	LL-i	LL-itì	LL-i-A(l)	LL-i-è	LL-iti-A(l)	HH-i-A(l)	HH-i-è	HH-iti-A(l)
II,2b	*kaun ‘grind’	HH-ì	HH-ì	HF-Ø	LL-i	LL-i	LF-Ø	LL-i-A(l)	LL-i-è	LL-è	HH-i-A(l)	HH-i-è	HH-è
IIIa	arr ‘measure’	HH-ì	HH-à	HH-èl	LH-ì	LH-à	LH-èl	LH-è	LH-e	LH-èl-à	HH-è	HH-e	HH-èl-à
IIIb	awi ‘pound’	HH-ò	HH-ò	HH-èl	LH-ò	LH-ò	LH-èl	LH-è	LH-e	LH-èl-à	HH-è	HH-e	HH-èl-à
IIIc	dus ‘tear’ (tr)	HH-ò	HH-ò	HH-èl	LF-Ø	LH-ò	LH-èl	LH-è	LH-e	LH-èl-à	HH-è	HH-e	HH-èl-à
IIId	*kair ‘stop’ (itr)	HF-Ø	HH-à	HH-èl	LF-Ø	LH-à	LH-èl	LH-è	LH-e	LH-èl-à	HH-è	HH-e	HH-èl-à
IIIe	*tai ‘hold, seize’	HF-Ø	HH-à	HH-èl	LF-Ø	LH-ò	LH-èl	LH-è	LH-e	LH-èl-à	HH-è	HH-e	HH-èl-à
IVa	jum ‘cover’	HF-Ø	HH-ò	HH-èl	LF-Ø	LH-ò	LH-èl	LH-Al	LH-e	LH-èl-à	HH-Al	HH-e	HH-èl-à
IVb	bul ‘find’	HH-ò	HH-ò	HH-èl	LH-ò	LH-ò	LH-èl	LH-Al	LH-e	LH-èl-à	HH-Al	HH-e	HH-èl-à
IVc	juuN ‘terrify’	HF-Ø	HH-à	HH-èl	LF-Ø	LH-à	LH-èl	LH-Al	LH-e	LH-èl-à	HH-Al	HH-e	HH-èl-à
IVd	kur ‘touch’	HH-à	HH-à	HH-èl	LH-à	LH-à	LH-èl	LH-Al	LH-e	LH-èl-à	HH-Al	HH-e	HH-èl-à

Shaded cells represent dynamic principal parts in one optimal principal-part analysis.

(Source: Jakobi 1990:103-113)

Whether one takes account of the tonality of the root (as in Table 30) or not--that is, even if one restricts one’s attention purely to the affixes used in conjugation (as in Table 31)--there are nineteen conjugations in Fur.

TABLE 31. Affixal exponents of Fur conjugations

Conjugation	Examples	Nonthird person			Third person								
					Singular			Plural					
								Nonhuman			Human		
		Subj	Perf	Pres	Subj	Perf	Pres	Subj	Perf	Pres	Subj	Perf	Pres
I,1a	buuN ‘descend’	-o	-ò	-èl	-o	-ò	-èl	-òl	-ùl	-èl-à/-ì	-òl	-ùl	-èl-à/-ì
I,1b	jaan ‘wait’	-o	-ò	-Ø	-o	-ò	-Ø	-òl	-ùl	-è	-òl	-ùl	-è
I,1c	irt ‘shake’	-o	-ò	-ì	-o	-ò	-ì	-òl	-ùl	-è	-òl	-ùl	-è
I,2a	tall ‘chew’	-ò	-o	-èl	-o	-ò	-èl	-òl	-ùl	-èl-à/-ì	-òl	-ùl	-èl-à/-ì
I,2b	fuul ‘spin’	-ò	-o	-Ø	-o	-ò	-Ø	-òl	-ùl	-è	-òl	-ùl	-è
I,2c	kir ‘cook’	-ò	-o	-ì	-o	-ò	-ì	-òl	-ùl	-è	-òl	-ùl	-è
II,1a	rii ‘snatch’	-i	-i	-itì	-i	-i	-itì	-i-A(l)	-i-è	-iti-A(l)	-i-A(l)	-i-è	-iti-A(l)
II,1b	tiir ‘meet’	-i	-i	-Ø	-i	-i	-Ø	-i-A(l)	-i-è	-è	-i-A(l)	-i-è	-è
II,2a	*faul ‘open’	-ì	-ì	-itì	-i	-i	-itì	-i-A(l)	-i-è	-iti-A(l)	-i-A(l)	-i-è	-iti-A(l)
II,2b	*kaun ‘grind’	-ì	-ì	-Ø	-i	-i	-Ø	-i-A(l)	-i-è	-è	-i-A(l)	-i-è	-è
IIIa	arr ‘measure’	-ì	-à	-èl	-ì	-à	-èl	-è	-e	-èl-à	-è	-e	-èl-à
IIIb	awi ‘pound’	-ò	-ò	-èl	-ò	-ò	-èl	-è	-e	-èl-à	-è	-e	-èl-à
IIIc	dus ‘tear’ (tr)	-ò	-ò	-èl	-Ø	-ò	-èl	-è	-e	-èl-à	-è	-e	-èl-à
IIId	*kair ‘stop’ (itr)	-Ø	-à	-èl	-Ø	-à	-èl	-è	-e	-èl-à	-è	-e	-èl-à
IIIe	*tai ‘hold, seize’	-Ø	-à	-èl	-Ø	-ò	-èl	-è	-e	-èl-à	-è	-e	-èl-à
IVa	jum ‘cover’	-Ø	-ò	-èl	-Ø	-ò	-èl	-Al	-e	-èl-à	-Al	-e	-èl-à
IVb	bul ‘find’	-ò	-ò	-èl	-ò	-ò	-èl	-Al	-e	-èl-à	-Al	-e	-èl-à
IVc	juuN ‘terrify’	-Ø	-à	-èl	-Ø	-à	-èl	-Al	-e	-èl-à	-Al	-e	-èl-à
IVd	kur ‘touch’	-à	-à	-èl	-à	-à	-èl	-Al	-e	-èl-à	-Al	-e	-èl-à

Only the two affixal exponents in heavy boxes are class-identifiers.
Shaded cells represent dynamic principal parts in one optimal principal-part analysis.

(Source: Jakobi 1990:103-113)

The number of dynamic principal parts for a Fur conjugation class depends on whether one takes account of tonality. The two possibilities are given in Table 32. In this table, the lefthand column indicates the number of dynamic principal parts needed to identify each conjugation if only affixes are taken into account; the righthand column indicates the number required if root tonality as well as affixes are taken into account.

TABLE 32. Number of dynamic principal parts needed to identify each Fur conjugation

Conjugation	Number of dynamic principal parts	
	With only affixes taken into account	With tonality and affixes both taken into account
IIIa; IVd	1 (class-identifier)	1
I,1a; I,1c; I,2a; I,2b; I,2c; II,1a; II,2a; II,2b	2	1
I,1b; II,1b; IIIb; IIIc; IIIe; IVa; IVb	2	2
IIId; IVc	3	3

As the first column of Table 32 shows, only two of the nineteen conjugations have a class-identifier among their affixal exponents. By the assumptions of the NBP, all of the other affixes in each column of Table 31 should be the class-default for that column; but this means that every one of the columns (= every morphosyntactic property set) in Table 33 has more than one class-default--contrary to the assumptions of the NBP.

Cameron-Faulkner & Carstairs-McCarthy (2000) discuss an apparently similar instance from Polish in which a particular morphosyntactic property set (locative singular) seemingly has more than one class-default, namely the suffixes *-e* and *-u*. They argue, however, that these two suffixes actually constitute a single default, since they are in complementary distribution: *-e* only appears in combination with a lexeme's special "minority" stem alternant, and *-u* appears elsewhere. In this way, they claim, the Polish evidence can be reconciled with the NBP.

This same strategy won't work for Fur, however. Notice, for example, that in the nonthird person perfect, some conjugations exhibit a low-toned *-à* suffix and others exhibit a low-toned *-ò* suffix. Yet, the paradigms of conjugations exhibiting the *-à* suffix may exhibit exactly the same pattern of stem tonality as those of conjugations exhibiting the *-ò* suffix. For instance, Conjugations IIIe and IVa differ in that the first shows the *-à* suffix and the second shows the *-ò* suffix; yet, these two conjugations exhibit precisely the same pattern of stem tonality, and the two suffixes are therefore in contrastive rather than complementary distribution. More generally, for each of the six sets of conjugations listed in (16), the only differences in exponence between the conjugations are affixal, and none of the distinguishing affixes is a class-identifier. These facts lead inevitably to the conclusion that the NBP cannot be maintained.

(16) a. I-1a, I-1c and II-1a
b. I-1b and II-1b
c. I-2a, I-2c and II-2a
d. I-2b and II-2b
e. IIIb and IVb
f. IIId, IIIe, IVa and IVc

The theoretical antecedent of the No-Blur Principle is the Paradigm Economy Principle (Carstairs 1987), which Carstairs-McCarthy (1991: 222) formulates as in (17):

(17) Paradigm Economy Principle
There can be no more inflectional paradigms for any word-class in any language than there are distinct "rival" inflectional realizations available for that morphosyntactic property-combination where the largest number of rivals compete.

As with the No-Blur Principle, it is intended that this principle be interpreted as relating specifically to affixal inflection; thus, it entails that the maximum number of conjugations in Fur should be no larger than the maximum number of affixes that compete to realize the same property set in Fur verbal inflection. Just as the Fur evidence fails to confirm the predictions of the No-Blur Principle, it likewise fails to confirm the predictions of principle (17): in Fur, the largest number of "rival" suffixes for the inflection of a particular morphosyntactic property set is six (in both the nonthird-person subjunctive and the third-person singular subjunctive; cf. Table 31)--far fewer than the total number of conjugations (of which there are nineteen). While the benefits of paradigm economy for language learning cannot be doubted, these facts show that paradigm economy is not clearly enforced by any grammatical constraint.

VII. Paradigmatic transparency as a dimension of typological variation

Like the Comaltepec Chinantec facts, the Fur facts demonstrate that languages tolerate considerable variation in the amount of paradigmatic transparency that they exhibit. The relevant Fur facts are summarized in Table 33, where conjugations are distinguished according to four criteria: according to the number of dynamic principal parts required to characterize them, according to the average number of principal parts needed to deduce an individual cell in a lexeme's paradigm, according to the number of alternative optimal principal-part analyses available to them, and according to their paradigm predictability.

TABLE 33. Degrees of transparency exhibited by Fur conjugations
(with tonality as well as affixes taken into account)

Conjugation	Number of dynamic principal parts	Average number of principal parts needed to deduce a particular cell in a lexeme's paradigm	Number of optimal analyses	Paradigm predictability
I,1a ; II,1a ; II,2a	1	1.00	4	0.923
I,2a	1	1.00	3	0.922
II,2b	1	1.00	1	0.921
II,1b	2	1.00	32	0.918
I,1c ; I,2c ; IVd	1	1.00	2	0.707
IIIa	1	1.00	1	0.707
I,2b	1	1.00	1	0.706
I,1b	2	1.00	16	0.703
IVb	2	1.00	4	0.491
IVa	2	1.17	1	0.399
IVc	3	1.00	8	0.333
IIIb	2	1.00	2	0.309
IIIc ; IIIe	2	1.33	1	0.273
IIId	3	1.00	4	0.206

The measure of paradigm predictability reveals some significant typological contrasts between Comaltepec Chinantec and Fur. By this measure, Comaltepec Chinantec tolerates a lower degree of paradigmatic transparency than Fur does: more than a fourth of the conjugations in Comaltepec Chinantec have a paradigm predictability below 0.2, while none of the Fur conjugations has a paradigm predictability this low. This difference in tolerance is reflected in a number of ways. First, Comaltepec Chinantec has optimal analyses involving as many as four principal parts, in comparison with a maximum of three in Fur. Second, seventeen of the sixty-seven conjugations in Comaltepec Chinantec involve paradigms at least some of whose words have to be deduced by simultaneous reference to more than one principal part; in Fur, by contrast, only three of the nineteen conjugations involve paradigms some of whose words have to be deduced through simultaneous reference to more than one principal part. Third, Comaltepec Chinantec provides an example of a conjugation (namely P3E) requiring four principal parts but allowing only one analysis out of a logically possible 495; Fur presents no conjugation class with a comparably constrained number of analyses. And fourth, well over half of the conjugations in Comaltepec Chinantec include one or more cells having a cell predictability of 0; by contrast, only four of the ninteen conjugations in Fur (namely IIIb, IIIc, IIId, and IIIe) have unpredictable cells, and none has more than one unpredictable cell. Nothwithstanding the fact that Comaltepec Chinantec clearly tolerates a lower degree of paradigmatic transparency than Fur, it does, at the same time, achieve maximal transparency in four conjugations, which no conjugation does in Fur.

VIII. Conclusions and projections for future research

Past research in morphological typology has tended to focus on the structure of individual word forms, invoking such criteria as the average number of morphemes per word form and the degree of morpheme fusion within a word form. The criteria proposed here extend the focus of typological classification from the structure of individual word forms to that of whole paradigms and to the implicative relations that paradigms embody.

As we have shown, languages differ considerably in the extent to which they exhibit paradigmatic transparency. In view of the prima facie benefits of paradigmatic transparency for language learning and lexical storage, it is initially somewhat unexpected that languages should differ in this way. But paradigmatic transparency is by no means the only property of inflectional systems that may confer benefits on the language user. Transparadigmatic transparency--the ease with which a cell in one paradigm can be deduced from the corresponding cell in another paradigm--surely confers benefits of this sort; for instance, knowing that 1pl present indicative forms are alike across all conjugations makes the 1pl present indicative form of a newly learned verbal lexeme immediately deducible from those of existing lexemes. Yet, the grammatical patterns that constitute paradigmatic transparency may be essentially the opposite of those constituting transparadigmatic transparency: a language all of whose conjugations possess maximal paradigmatic transparency (cf. again Figure 1) possesses minimal transparadigmatic transparency; by the same token, a language in which distinct conjugation classes participated in a high degree of transparadigmatic transparency would inevitably exhibit low paradigmatic transparency. Thus, to understand the cross-linguistic variability of paradigmatic transparency, it will ultimately be necessary to understand the ways in which this property interacts with, counterbalances, or compensates for other, different grammatical properties.

Another parameter relevant for the analysis of paradigmatic transparency is that of frequency. Given any two cells *A*, *B* in a paradigm, one can calculate the probability that a particular exponent *a* for cell *A* will coincide with a particular exponent *b* for cell B; if exponents *a* and *b* coincide more often than they fail to coincide, then paradigms in which they coincide would, to that extent, be more transparent than paradigms in which they fail to coincide (cf. Ackerman & Malouf 2006). Thus, issues of probability also have a role to play in a more complete elaboration of the notion of paradigmatic transparency. These and other, related issues await further research.

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