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Matteo Pellegrini

Paradigm Structure and Predictability in Latin Inflection

An Entropy-based Approach



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Preface

In the last few years, the field of morphology has started to question some fundamental assumptions on the structure of wordforms. In particular, the idea is gaining ground that wordforms should not be viewed as obtained by concatenating smaller meaningful pieces one to another, as in classical morphemic analysis. Instead, the opposite happens: from the comparison of fully inflected wordforms, recurrent partials are extracted which can be thought of as having a discriminative function within the paradigm—i.e. what matters is that they are useful in order to distinguish wordforms from one another, rather than their association with a particular meaning.

A problem that has been widely investigated in this context is the possibility of predicting fully inflected wordforms from one another within the inflectional paradigm of a lexeme, exploiting the presence of more or less reliable implicative relations, in what has been labelled the “Paradigm Cell Filling Problem”. As a way of quantifying the difficulty of this task, the information-theoretic notion of conditional entropy has been used in much recent work.

In this work, the above-mentioned theoretical and methodological innovations are exploited to investigate the Latin verbal and nominal paradigm, to obtain a quantitative analysis of the reliability of implicative relations, and thus of the patterns of interpredictability between inflected wordforms—i.e. of the difficulty of the Paradigm Cell Filling Problem. Hence, this book is the most complete up-to-date application currently available in the literature of this theoretical and methodological framework to the morphological system of a single language.

This work also provides a careful explanation of the details of the procedure followed to gather the required data and of the way the available tools have been used to obtain the results. By doing so, it can serve as a gentle introduction to this framework for the many scholars that investigate related issues of paradigm structure and morphological complexity, especially (but not only) on Romance languages. Hopefully, this might convince them to apply it to the languages they work on, making larger-scale interlinguistic and typological comparisons possible. Indeed, since creating the datasets necessary to perform such an analysis is quite time-consuming and requires a very good knowledge of the morphological system

involved, it proves to be difficult to have a large enough sample of languages through the work of one person only. Hence, the approach can only benefit from having more people applying it to diverse data.

Furthermore, applying the methodology carefully is a way to put this approach to the test empirically, showing its strengths, but also identifying ways in which it can be improved by taking into account other factors (namely, gender and derivation, as will be detailed in the remaining part of this introduction and—more extensively—in the rest of the book itself).

As a consequence, the contribution that this work is intended to provide to the advancement of research is twofold: to the description of Latin inflectional morphology on the one hand and to morphological theory and methodology on the other hand. However, it is important to note that these two aspects are closely intertwined. Indeed, the main appeal of the new description of Latin sketched in the book is to be found in its theoretical and methodological framework: it is exactly the adoption of a fully word-based abstractive approach, coupled with its implementation in a principled procedure, which uncovers aspects of Latin morphology that have been downplayed in previous descriptions and theoretical studies. Conversely, the contribution of the work to morphological theory is made possible by the fact that the entropy-based methodology is applied thoroughly to the morphological system of a language, identifying new, potentially relevant factors that have not been taken into consideration in previous research.

The book is divided into six chapters. Chaps. 1 and 2 provide a more detailed picture of the theoretical framework within which this work is located and of the adopted, entropy-based, methodology, respectively. As we will see in more detail in Chap. 1, our theoretical framework can be considered as abstractive—i.e. considering morphemes as possibly extracted *a posteriori* from fully inflected wordforms, rather than starting from morphemes and assembling them to obtain wordforms—and implicative—i.e. focusing on implicative relations, rather than on exponence of morphosyntactic properties. Our approach is also quantitative, as the entropy-based assessment of predictability in inflectional paradigms is obtained by taking the type frequency of different inflectional patterns into account—as is shown in Chap. 2, where the details of the adopted methodology are outlined.

To obtain information on the type frequency of inflectional patterns, an inflected lexicon listing the wordforms of a representative selection of lexemes is necessary. In Chap. 3, the lexical resource that was created for the purposes of this work—LatInfLexi—is presented, showing how it was obtained from the large database of a recently renewed morphological analyser of Latin, Lemlat 3.0.

We can then move to the presentation of our results on verb paradigms—in Chap. 4—and on noun paradigms—in Chap. 5. On the one hand, such results are exploited to obtain a mapping of the paradigm in zones of interpredictability—i.e. groups of cells that can be predicted from one another with no uncertainty. On the other hand, if not only predictions from one cell but also predictions from more than one cell are taken into account, principal parts—i.e. sets of cells from which the whole paradigm of a lexeme can be inferred without uncertainty—or at least near

principal parts—which reduce uncertainty greatly, but not completely—can be found in a more principled way than in traditional descriptions.

In the last section of Chap. 5, a methodological innovation with respect to the standard procedure is introduced. In Sect. 5.3, uncertainty in predicting one cell from another is quantified assuming that not only the phonotactic shape of the wordforms is known, but information of a different kind too—namely, the gender of a noun, which is partly predictive of its inflectional behaviour, as is already acknowledged in traditional descriptions. The entropy-based methodology allows us to quantify the degree of the reduction in uncertainty obtained by including gender information.

In Chap. 6, another piece of information is assumed to be known besides phonotactics, namely the derivational relatedness of lexemes in our sample, in terms of both families—which for practical reasons we investigate in verb paradigms—and series—studied in noun paradigms. The interpretation of the results of this last chapter raises interesting methodological and theoretical questions on how to count different lexemes that share the same lexical base (cf. the classification in families), and different lexemes that are built by means of the same derivational process (cf. the classification in series). Do these derivationally related lexemes constitute different types when quantifying the type frequency of different patterns, as usual in entropy-based analyses, or should they rather be grouped under the same type?

In conclusion, we summarize the contribution provided by this work to the description of Latin inflectional morphology and to the theoretical and methodological framework of abstractive, implicative approaches, but also to the set of language resources available for Latin. Finally, we briefly sketch some ideas for future work on the comparison of predictability and paradigm organization in Latin and in the Romance languages.

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Contents

1	The Theoretical Framework	1
1.1	Some Definitions	1
1.2	Classifications of Theories of Inflectional Morphology	4
1.3	Implicative Relations, Words and Sub-word Units	10
1.3.1	Implicative Relations and Exponents	10
1.3.2	Implicative Relations and Stem Allomorphy	11
1.3.3	Putting It All Together: Implicative Relations Between Words	13
1.4	The Quantitative Dimension	17
1.5	Conclusion: A Quantitative Abstractive Approach to the Implicative Structure of Paradigms	19
	References	19
2	The Method	23
2.1	Basic Information-Theoretic Notions	23
2.2	Predicting Exponents	26
2.3	Predicting Alternation Patterns	29
2.4	Predicting from More Than One Wordform	35
2.5	Predicting Forms Knowing More Than Just Forms	39
2.6	Conclusion: An Entropy-based Approach to the PCFP	40
	References	41
3	The Data and the Tools	43
3.1	The Structure of LatInfLexi	44
3.2	The Selection of Lexemes	45
3.3	The Generation of Wordforms	47
3.3.1	Verb Paradigms	48
3.3.2	Noun Paradigms	51
3.4	The Treatment of Overabundance	53
3.4.1	Overabundance Due to the Presence of More Than One LES	54

3.4.2	Overabundance Due to Compatibility of a LES with More Than One SF	57
3.5	Phonetic Transcriptions	59
3.6	Using Qumin	63
3.7	Conclusion: Using LatInfLexi for an Entropy-based Analysis of Latin Verb and Noun Paradigms	65
	References	66
4	Predictability and Paradigm Organization in Latin Verb Inflection	69
4.1	Latin Verb Inflection: The Traditional Account and Previous Theoretical Research	70
4.2	The Cell Paradigm of Latin Verbs	80
4.3	Predictability in Latin Verb Inflection	83
4.3.1	Wordforms that Are Based on Different Stems	83
4.3.2	Wordforms that Are Based on the Same Stem	89
4.4	Zones of Interpredictability in Latin Verb Inflection	94
4.5	<i>n</i> -ary Implicative Entropy and Principal Parts	99
4.6	Conclusion	106
	References	107
5	Predictability in Latin Noun Inflection and the Role of Gender	109
5.1	Latin Noun Inflection: The Traditional Account	110
5.2	Predictability in Latin Noun Inflection	119
5.2.1	The Cell Paradigm of Latin Nouns	119
5.2.2	Results: Unary Implicative Entropy	120
5.2.3	<i>n</i> -ary Implicative Entropy and Principal Parts	123
5.3	Predictability and Gender	130
5.3.1	Some Examples	130
5.3.2	Gender and Nominal Inflection Classes in Latin	134
5.3.3	Results	136
5.3.4	Discussion	140
5.4	Conclusion	142
	References	143
6	The Impact of Derivational Relatedness on Inflectional Predictions	145
6.1	The Question	146
6.2	Verbs that Derive from the Same Ancestor: Derivational-Inflectional Families	151
6.2.1	Coding Derivational-Inflectional Families	151
6.2.2	The Inflectional Behaviour of Verbs in the Same Family	155
6.2.3	Results	158
6.3	Nouns that Are Formed by Means of the Same Derivational Suffix: Derivational-Inflectional Series	161

6.3.1	Derivational-Inflectional Series: Coding and Inflectional Behaviour	161
6.3.2	Results	164
6.4	A Different Approach: Framing Inflectional Predictability as a Classification Problem	167
6.5	Discussion	172
6.6	Conclusion	176
	References	177
7	Conclusions	179
	References	182

Chapter 1

The Theoretical Framework



In this chapter, we will locate the approach that is adopted in this work in the larger field of theoretical morphology. To do so, we will discuss several points: each of them will be illustrated using examples taken from Latin inflectional morphology.

The point of departure will be an overview of the terminology that is used throughout this work (Sect. 1.1). We will then discuss several classifications of morphological theories (Sect. 1.2), from the traditional distinction between Item-and-Arrangement, Item-and-Process and Word-and-Paradigm models operated by Hockett (1954) up to the recent characterization of constructive and abstractive approaches proposed in Blevins (2006, 2016), highlighting the specific aspects on which each of the discussed classifications is based. In Sect. 1.3, we will focus on implicative relations, contrasting different ways in which they can be formulated, in terms of generalizations on exponents (Sect. 1.3.1), on stems (Sect. 1.3.2) or on inflected wordforms (Sect. 1.3.3). We will then add a quantitative dimension to the picture (Sect. 1.4), showing the importance of considering also non-categorical implicative relations. Lastly, in Sect. 1.5 we will explain the choices that have been made in this work regarding each of the topics discussed in the previous sections.

1.1 Some Definitions

It is useful to start by giving a precise definition of some basic terms. Although most of them are well known, at least since Matthews (1974), they sometimes appear with slightly different meanings in different studies.

Let us consider the data in Table 1.1.¹

¹The examples used in this chapter constitute only small fragments of the much more complex inflectional system of Latin: therefore, in principle the generalizations that are drawn are to be

Table 1.1 The paradigm of two Latin nouns

	NOM. SG	GEN. SG	DAT. SG	ACC. SG	VOC. SG	ABL. SG	NOM. PL	GEN. PL	DAT. PL	ACC. PL	VOC. PL	ABL. PL
LUPUS 'wolf'	<i>lupus</i>	<i>lupī</i>	<i>lupō</i>	<i>lupum</i>	<i>lupē</i>	<i>lupō</i>	<i>lupī</i>	<i>lupōrum</i>	<i>lupīs</i>	<i>lupōs</i>	<i>lupī</i>	<i>lupīs</i>
MURUS 'wall'	<i>mūrus</i>	<i>mūrī</i>	<i>mūrō</i>	<i>mūrum</i>	<i>mūre</i>	<i>mūrō</i>	<i>mūrī</i>	<i>mūrōrum</i>	<i>mūrīs</i>	<i>mūrōs</i>	<i>mūrī</i>	<i>mūrīs</i>

In the terminology proposed by Matthews (1991: 24 ff.), each slot of the table is said to contain a different **word** (in italics in our table). For instance, the first case contains the word *lupus*. A word is defined by Matthews (1991: 31) as a concrete linguistic sign, whose *signifiant* is called a **wordform**. For instance, the word *lupus* consists of the sequence of phonemes /lupus/.² On the other hand, the *signifié* of a word comprises both lexical and morphosyntactic information, i.e. information on the **lexeme** and **morphosyntactic property set** which the word expresses.

A **morphosyntactic property** is the pairing of a feature with the specific value that it takes. In Latin, there are two morphosyntactic features for which a noun is inflected: there is the feature CASE, whose different possible values are NOMINATIVE, GENITIVE, ACCUSATIVE, DATIVE, VOCATIVE and ABLATIVE,³ and the feature NUMBER, whose different values are SINGULAR and PLURAL. If we combine the different values of these two morphosyntactic features, we obtain 12 different **morphosyntactic property sets** (henceforth sometimes referred to also by means of the abbreviation MPS), corresponding to the headers of the columns of the table. Morphosyntactic property sets thus refer to the portion of meaning of a wordform that is relevant for syntax, rather than to its referential semantics. To express morphosyntactic property sets, throughout this work we will use the abbreviations of the Leipzig Glossing Rules, with values of different features separated by a dot: therefore, NOM.SG is to be taken as a shorthand for the feature:value pairings CASE:NOMINATIVE and NUMBER:SINGULAR.

In our table, the headers of the lines are **lexemes**, i.e. abstract lexical units comprising all the inflected wordforms that share a core lexical meaning, differing only in the morphosyntactic property sets that are expressed. Lexemes, like LUPUS and MURUS, will be notated in small capitals (as is usual in morphology), using the inflected wordform realizing the morphosyntactic property set NOM.SG (as is usual in Latin linguistics) as a **citation form** for nouns, and the one realizing the PRS.ACT. IND.1SG for verbs (PRS.PASS.IND.1SG for deponents).⁴

Throughout this work, we will stick to Matthews' terminology, the only difference being that we will avoid the term "word", that could generate some unclarity, since it is normally used in the literature also for what we call "lexemes". We will rather follow the standard usage of the specifically morphological literature, extending the coverage of the term "(inflected) wordform" also to cases where we need to refer to the elements that appear in paradigms as two-sided linguistic signs, considered not only in their formal aspects, but also in their semantic ones.

considered as valid only regarding the data of the examples, and not in Latin in general (although in many cases their reliability is indeed wider).

²The IPA transcriptions provided in this work are the ones that are given in LatInfLexi, on which see Chap. 3 below.

³For some lexemes, and only in the singular, there is also another value of this feature, namely the LOCATIVE, that we omit here for the sake of simplicity (see also the discussion in Sects. 3.3.2 and 5.1 below).

⁴It should be noticed that throughout this work information on vowel length will be systematically omitted in the notation of lexemes—but not of wordforms.

With these definitions in mind, we can now follow Stump and Finkel (2013: 9) in defining the **paradigm** of a lexeme as a complete set of **cells**, where each cell is the pairing of that lexeme with the morphosyntactic property set for which it is inflected. Following Stump (2006: 284) and Boyé and Schalchli (2016: 207), a distinction can be made between the abstract **content paradigm**, given by the different morphosyntactic property sets for which lexemes of a given category can be inflected (the headers of the columns in our table can be taken as a notation of the content paradigm of Latin nouns), and the concrete **form paradigm**, consisting of the wordforms that are used to realize the content paradigm for a specific lexeme (the different lines in our table, that give us the form paradigm of the Latin nouns LUPUS and MURUS).

Lastly, it is useful to have a working definition of “stem” and “exponent”, although the notions to which these terms refer will be problematized in Sect. 1.3. For a given wordform, the **stem** is the portion of form that contributes lexical information, while the **exponent** is the portion of form that contributes information on the morphosyntactic property set that is expressed (cf. Beniamine 2018: 37). For instance, in the wordform *lupe*, the sequence *lup-* can be identified as the stem, since it appears in all the wordforms of the lexeme LUPUS and it does not appear in any wordform of the lexeme MURUS. On the other hand, the ending *-e* will be the exponent of the morphosyntactic property set VOC.SG, since it only appears in that cell across lexemes—in this example, both in LUPUS and in MURUS. Since LUPUS and MURUS use the same exponents for each morphosyntactic property set, they can be said to belong to the same **inflection class**, whereas other lexemes would use different exponents for the same morphosyntactic property sets, thus being assigned to different inflection classes.

1.2 Classifications of Theories of Inflectional Morphology

Many classifications of theories of inflectional morphology have been proposed, each of them based on specific aspects that are taken to be more relevant. Perhaps the most classical distinction was first stated by Hockett (1954), who distinguishes three different models that he calls “Item-and-Arrangement” (henceforth IA; cf. e.g. Harris 1942), “Item-and-Process” (henceforth IP, defended by Hockett 1954 himself) and “Word-and-Paradigm” (henceforth WP, further elaborated by Robins 1959 and Matthews 1972).

This classification is not completely symmetric in the characteristics that are used to distinguish the different models. In both IA and IP, the basic unit is the morpheme; the two models only differ in the type of operations—arrangements or processes—that need to be applied to such units in order to obtain larger units—namely, fully inflected wordforms. On the other hand, in WP models, inflected wordforms are considered as the basic unit of morphosyntactic content, and their associations with morphosyntactic properties is specified by their location in paradigms (cf. Robins 1959: 60).

Table 1.2 Stump (2001)’s classification of morphological theories

	Incremental theories (exponents → MPS)	Realizational theories (MPS → exponents)
Lexical theories (exponents as lexical items)	Lexical-incremental (Lieber 1992)	Lexical-realizational (Halle and Marantz 1993)
Inferential theories (exponents as processes)	Inferential-incremental (Steele 1995)	Inferential-realizational (Stump 2001)

Another well-known classification of morphological theories has been proposed by Stump (2001) and is based on two cross-cutting distinctions, both related to the different ways in which the associations between morphosyntactic properties and exponents are treated in different models. The first distinction, between what Stump calls “lexical” and “inferential” theories, is similar to the difference between IA and IP, in that it concerns the nature of the associations. In lexical theories, they are listed in the lexicon, in the same way as the association between “roots” and “their grammatical and semantic properties” (Stump 2001: 1). Let us consider again the vocative singular of *LUPUS*. According to lexical theories, there would be a lexical entry for the affix *-e*, specifying its phonological shape /*e*/ and the morphosyntactic property set that it expresses (namely, *voc.sg*), exactly like there is a lexical entry for the lexeme, specifying the phonology of the stem /*lup*/ and the meaning ‘wolf’, as well as other grammatical information—for instance the masculine gender. In inferential theories, on the other hand, the associations are expressed via morphological rules that relate a stem to a specific inflected wordform: in this example, there would be a process of suffixation of *-e* that is applied to the stem *lup-* to yield the inflected wordform *lupe*.

The second distinction, between “incremental” and “realizational” theories, concerns the direction of the association. In incremental theories, exponents enable wordforms to acquire morphosyntactic information; when *-e* is added, the wordform acquires the morphosyntactic property set *voc.sg*. Conversely, in realizational theories, the fact that a wordform expresses a morphosyntactic property set licenses the introduction of the corresponding exponent; when the lexeme *LUPUS* appears in a context that requires the properties *voc.sg*, the exponent *-e* is used.

Table 1.2 summarizes the possible combinations of the different distinctions, providing examples for each type of theory (taken from Stump 2001: 2–3).

In such a framework, WP models are considered by Stump (2001) as realizational, in that they take fully inflected wordforms as the basic units of content. However, this does not imply that wordforms are also considered to be the basic units of form: this point is explicitly rejected by Robins (1959: 52), according to whom “WP must recognize the morpheme as the minimal grammatical (not semantic!) unit of a language”.

This discrepancy was put to the fore by Blevins (2006, see also Blevins 2016 for a more detailed picture), who distinguished between **constructive** and **abstractive** approaches. Constructive approaches are morph-based (Blevins 2006: 533), since sub-word units like stems and exponents are taken to be the basic units of form, the

Table 1.3 Some paradigm cells of five Latin nouns

Lexeme (declension)	GEN.SG	DAT.SG	GEN.PL	DAT.PL
ROSA ‘rose’ (1 st declension)	<i>rosae</i>	<i>rosae</i>	<i>rosārum</i>	<i>rosīs</i>
LUPUS ‘wolf’ (2 nd declension)	<i>lupī</i>	<i>lupō</i>	<i>lupōrum</i>	<i>lupīs</i>
DUX ‘leader’ (3 rd declension)	<i>ducis</i>	<i>ducī</i>	<i>ducum</i>	<i>ducibus</i>
FRUCTUS ‘fruit’ (4 th declension)	<i>frūctūs</i>	<i>frūctuī</i>	<i>frūctuum</i>	<i>frūctibus</i>
RES ‘thing’ (5 th declension)	<i>reī</i>	<i>reī</i>	<i>rērum</i>	<i>rēbus</i>

pieces with which larger units—i.e., inflected wordforms—are assembled. According to abstractive approaches, however, fully inflected wordforms are the basic unit of form, since smaller units like stems and exponents are taken to be secondary abstractions that are (possibly) extracted from wordforms.

In this sense, not only IA and IP models, but also most contemporary WP models can be considered as constructive and morph-based, since the wordform is the basic unit of meaning, but not of form (cf. Blevins 2016: 6 ff.). In realizational approaches like Paradigm Function Morphology (Stump 2001, Bonami and Stump 2016) and Network Morphology (Corbett and Fraser 1993, Brown and Hippisley 2012), inflected wordforms are generated starting from a set of stems to which a series of inflectional rules are applied.

Let us now consider a different aspect, by looking at the set of paradigm cells given in Table 1.3 for Latin nouns belonging to different declensions.

We can follow Bonami (2014: 23) in distinguishing **exponence** and **implicative relations**. In the graphical structure of Table 1.3, exponence is the “vertical” relationship between a wordform and the morphosyntactic property set that it expresses (cf. also Stump and Finkel 2013: 263). For instance, a generalization about exponence in this dataset can be formulated as in (1), stating that if a noun ends in *-rum* it will be a genitive plural.

(1) An example of exponence relation

$$N_{rum} \rightarrow \text{GEN.PL}$$

Implicative relations, on the other hand, refer to the “horizontal” relationship between a wordform in a given paradigm cell and another wordform in a different paradigm cell. For instance, knowing that a noun ends in *-ārum* in the genitive plural unambiguously identify it as belonging to the 1st declension, thus making it possible to infer its genitive singular by replacing *-ārum* with *-ae*. This generalization can be expressed as in (2).

(2) An example of implicative relation

$$N_{ārum, \text{ GEN.PL}} \rightarrow N_{ae, \text{ GEN.SG}}$$

There have been proposals to classify morphological theories according to the kind of relations that are given more prominence. For instance, according to Stump (2016: 257), the realization of paradigm cells can be given both an **exponence-based** and an **implicative** definition. Boyé and Schalchli (2016) accordingly identify **paradigmatic** frameworks as the ones that aim at an implicative definition, starting from