Monotonic Paradigmatic Schemata in Italian Verb Inflection(*)

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Abstract

In recent years, morphological paradigms have been the focus of an extensive investigation, which has thrown in sharp relief the descriptive adequacy of a paradigm-based approach to the Morphology of highly inflecting languages, with particular emphasis on notoriously thorny problems such as stem selection and stem choice in verb conjugation. Comparatively little has been done so far to show the practical descriptive advantages of an extensive use of paradigms in a computational system for word analysis/generation. In this paper we report in some detail the results of a fully developed, paradigm-based, computational treatment of the entire conjugational system of Italian. We focus on the considerable descriptive economy resulting from drawing on the amount of redundancy exhibited by the paradigmatic structure of both regular and irregular verbs in Italian. This redundancy, we suggest, is captured through so-called **paradigmatic schemata**. Our implementation compares favourably with other non-paradigmatic strategies in terms of both descriptive adequacy and economy.

1 Paradigm-Morphology and Italian inflection

Italian Inflection grudgingly lends itself to the notion that Morphology is an inventory of items, called **morphemes**, consisting of an arbitrary association of a form (a continuous phonological sequence or string of characters) and a well-defined unique portion of morphological meaning, expressed through morphosyntactic and/or lexical features. This difficulty is well exemplified by the present indicative of the verb TENERE ('keep'):

teng	*o*	*"I keep"*
tien	*i*	*"you keep"*
tien	*e*	*"(s)he keeps"*
ten	*iamo*	*"we keep"*
ten	*ete*	*"you keep"*
teng	*ono*	*"they keep"*

TENERE exhibits a variety of distinct stems in its inflection (*teng-*, *ten-* and *tien-* for the present indicative only), each of which can occur with particular inflectional endings and not with others. This property, which extends to all basic (i.e. non derivative and non inchoative) irregular Italian verbs (about 200) and has variously been characterised in the literature in terms of "reciprocal conditioning", "heteroclisis" and otherwise, raises the issue of what regular process governs stem selection. Traditionally, reciprocal conditioning has been accounted for either as a phenomenon of co-selection between two independently identified morphological units, or as a phonologically-governed alteration of the stem when in company of particular endings. With a good many verbs, among which TENERE is a case in point, however, the distributional difference between two stems can be inferred neither from any systematic difference in morphosyntactic feature content (which a single morphological unit is purported to convey), nor from ordinary phonological considerations. Paradigms offer an economic and elegant way to capture all these facts.

2 Stem Alternation and Choice

In Morphology, a verb paradigm defines a set of cells where fully inflected word forms are paired with a complete morphosyntactic feature specification reflecting the way relevant conjugational dimensions such as tense, mood, person, number, and verb class combine. Paradigms define a dimension of morphological analysis which cuts across the spectrum of both traditional morpheme- and process-based assumptions: stress is laid on the way morphological meaning is systematically structured in language, no matter what formal means are put to use to fill in a given paradigmatic cell (Matthews 1974, Carstairs 1988, 1992, Carstairs and Stemberger 1988, Calder 1989, Stump 1991). For convenience, we will hereafter assume that Italian paradigmatic cells are filled in through a basically concatenative operation, trailing an inflectional ending after a verb

stem. For a given verb class, each inflectional ending presupposes and is presupposed by any other paradigmatically-related inflectional ending (Wurzel 1989). This is illustrated in the examples of the present indicative paradigm of irregular Italian verbs given below, where a blank separates the stem from the inflectional ending[1].

present indicative

	TENERE		*VENIRE*
1*s*	*teng o*	1*s*	*veng o*
2*s*	*tien i*	2*s*	*vien i*
3*s*	*tien e*	3*s*	*vien e*
1*p*	*ten iamo*	1*p*	*ven iamo*
2*p*	*ten ete*	2*p*	*ven ite*
3*p*	*teng ono*	3*p*	*veng ono*

	DOLERE		*COGLIERE*
1*s*	*dolg o*	1*s*	*colg o*
2*s*	*duol i*	2*s*	*cogl i*
3*s*	*duol e*	3*s*	*cogl e*
1*p*	*dol iamo*	1*p*	*cogl iamo*
2*p*	*dol ete*	2*p*	*cogl ete*
3*p*	*dolg ono*	3*p*	*colg ono*

Besides the **intralexemic** character of Wurzel's presupposition relation paradigms also exhibit systematic **interlexemic** redundancies in stem selection (Pirrelli and Federici 1994). TENERE and VENIRE ('come'), in spite of their belonging to different conjugational classes (respectively second and third), exhibit an identical pattern of stem alternation, as illustrated in the **paradigmatic schema** of grid 1 below, where sameness of index expresses sameness of stem formation:

1)

1*s*	r2
2*s*	r3
3*s*	r3
1p	r1
2p	r1
3p	r2

2)

1*s*	r2
2*s*	r1
3*s*	r1
1p	r1
2p	r1
3p	r2

3)

1*s*	r2
2*s*	
3*s*	
1p	r1
2p	r1
3p	r2

The grid is also applicable to the present indicative of DOLERE ('hurt') given above, independently of the substantial variation in phonological content between the stems of DOLERE and those of VENIRE and TENERE. When things are observed at the proposed level of abstraction, surprisingly few paradigmatic schemata, unspecified for phonological content and combined with appropriate conjugational classes of endings, suffice to generalize over the entire Italian conjugation system (Spencer 1988, Pirrelli 1993).

There exists a direct relationship between the number of stem alternants of a verb and the paradigmatic schema the verb conforms to. Under the assumption that three stem alternants *r1*, *r2* and *r3* are used for present indicative, they most often distribute according to grid 1 above. Similarly, the present indicative of a two-stem verb rarely departs from grid 2.

There is a nonempty intersection between schemata 1 and 2 (grid 3): a certain amount of combinatoric redundancy carries over from a three-stem paradigm to a two-stem paradigm. In particular, i) the same stem shows up in the first-person singular and third-person plural, ii) *r1* has the same distribution in the two schemata, iii) *r1* occupies the slots left empty by the missing third stem alternant, so that the constraint that stem alternants in cells 2s and 3s are assigned the same index is not violated. A quick look at the paradigm of completely regular verbs (i.e. verbs with no stem alternation) confirms this trend: *r2* disappears, but its slots are taken over by *r1*. In a nutshell, *r1* is the default surface stem alternant and normally occupies slots which are left empty by nonexisting alternants.

The descriptive economy obtained by describing inflectional paradigms through paradigmatic schemata is considerable. Due to the distributional overlapping between three-stem paradigms and paradigms with fewer alternants, a single schema, specified for the maximum number of possibile stem alternants, suffices to account for the distribution of an entire class of verb alternants, when the following simplified **General Indexing Convention** (GIC) is resorted to: a) *assign the default index r1 to the stem occurring in the cell of the* **second-person plural of present indicative**; b) *assign r2 to the stem of the* **first-person singular of present indicative**; c) *assign r3 to the stem of the* **second-person singular of present indicative**.

In the following section we will detail a straightforward monotonic formalization of a), b) and c) in a typed feature-structure formalism. Suffice it to say now that GIC makes reference to distributional properties only, specified in terms of the number of stem alternants that a lexeme exhibits. No mention is made either of the alteration which the stem undergoes or of the form of the corresponding inflectional ending. This is grounded on the **Indexing Autonomy Hypothesis** (IAH), according to which "stem pairs exhibiting an identical contrast in formation needn't exhibit an identical contrast in indexing" (Stump 1995). At first glance, the parallel distributional and formal behaviour of stem alternants in the present indicative of TENERE and VENIRE seems to falsify IAH. Other evidence, however, shows that IAH is indeed descriptively adequate. Consider, for concreteness, the alternation in stem pairs such as *crocifigg-ete* ('you crucify')/ *crocifiss-i* ('I crucified'), *infligg-ete* ('you inflict')/ *infliss-i* ('I inflicted'). In spite of their similarity in stem formation, matched by partial distributional redundancies, any direct correlation between phonolog-

[1] In the paradigm of *cogliere* the stem alternant *cogl-* is turned into *cogli-* in the third-person singular and second-person plural of the present indicative by some separate readjustment rules.

ical and distributional regularities would lead to incorrect paradigmatic statements, as shown by the contrast between the past participle *crocifisso* ('crucified') and the past participle *inflitto* ('inflicted') where yet another stem alternant shows up. Note that IAH does not exclude the possibility that a direct correlation between form and indexing can be stipulated conveniently. A more highly valued lexicon should also be able to capture the striking similarity between the present indicative of both TENERE and VENIRE shown above. We will consider this possibility in the final part of the paper.

3 An ALEP Implementation

We illustrate here a formalization of the paradigm-based model outlined above, couched in the typed-feature structure formalism of ALEP[2] (Cray Systems 1994, Battista and Pirrelli 1995, Battista et al. 1995).

Following Stump (1995), a paradigm-based treatment of Italian verb inflection requires at least three logically distinct types of formal devices: a) word-formation rules; b) paradigmatic schemata, which select differently indexed stem alternants depending on paradigmatic distribution; c) indexing schemata, which assign stem alternants the indices to which paradigmatic schemata are sensitive.

We avail ourselves of a single word-formation rule (WFR), which enforces, in the ALEP parlance, morphotactic constraints on the compatibility of a stem and inflectional ending in an inflected form:

```
ld:{spec=>specif:{proc_type=>proc_type:{process=>y},
                  data_type=>wsr:{wsr_id=>ID}},
   sign=>sign:{phon =>[R,E],
               constype=>word:{},
               synsem=>synsem:{
                 local=>local:{
                   syn=>syn:{
                     cat=>head_cat:{
                       head=>HEAD}}}}}}

  <[

ld:{spec=>specif:{data_type=>lex:{lex_id=>ID}},
   sign=>sign:{phon=>[R],
               constype=>morpheme:{
                 morphtype=>root:{
                   inflex=>INFLEX}}}},

ld:{sign=>sign:{phon =>[E],
                constype=>morpheme:{
                  morphtype=>i_ending:{
                    inflex=>INFLEX}},
                synsem=>synsem:{
                  local=>local:{
                    syn=>syn:{
                      cat=>head_cat:{
                        head=>HEAD}}}}}}
  ]
```

[2]The Advanced Language Engeneering Platform (ALEP) is an EC initiative to provide the natural language research and engeneering community in Europe with a general purpose research and development environment.

The rule is stated in traditional morphemic terms: a full word can be the mother node of a binary branching structure whose daughters are a stem and an inflectional ending. The immediate dominance relationship is expressed by '<'. Daughters are listed between square brackets, and separated by a comma in their precedence order. Feature structures are enclosed in curly brackets, and paths are expressed through right-pointed arrows:

attribute=>value

Feature structures are typed (TFSs), with the type name separated by a colon:

type_name: {feature_structure}

The rule says that a stem and an inflectional ending combine in an inflected word form if and only if their INFLEX TFSs are unifiable. Although Italian morphology is treated here as basically concatenative, the formal paradigm-based apparatus we propose here can variously be couched in either process-based or morpheme-based morphologies, the choice between the two being dictated only by empirical considerations concerning the mainly concatenative or nonconcatenative nature of the language in question (Matthews 1974, Calder 1989).

4 The Morphological Lexicon

The ALEP Italian morphological lexicon includes two basic entry types, stems and inflectional endings, both structured paradigmatically. A third type, covering all non inflecting items, will not be considered here.

A verb entry is encoded according to an appropriate **indexing schema** which conforms to GIC. In particular we use some ALEP macros such as the following:

```
macro( m_ROOT_WS1[LEX,PHON,INFLEX],
       ld:{spec=>specif:{proc_type=>proc_type:{tlm=>n,
                                               process=>y},
                         data_type=>lex:{lex_id=>LEX}},
           sign=>sign:{phon=>[PHON],
                       constype=>morpheme:{
                         morphtype=>root:{
                           tlm_class=>tlm_class:{velar=>n,
                                                 glide=>n},
                           inflex=>INFLEX}}}})
```

The m_ROOT_WS1 macro takes three arguments (between square brackets in the first line of the macro): LEX, which specifies the encoded lexeme as a value of the attribute 'lex_id', PHON, a possibly singleton list of the stem alternants of the lexeme in question, and INFLEX, which, among other things, enforces the relevant stem indexing schema. An instantiation of the arguments of this macro spells out the following lexical entry of the irregular verb SCENDERE ('get down'):

```
scendere ~
  m_ROOT_WS1[l_scendere,
      (scend/sces/sces)-alt,
      inflex:{inflex_class=>[v,e],
              paradigm_class=>(zero/ono/three)-alt,
              stem_index=>((r1;r2;r3;r5)/r4/r6)-alt}].
```

where LEX is instianted as 'l_scendere', PHON is assigned two stems (*scend-* and *sces-*), and INFLEX takes a disjunctive list of paradigmatic indices which correlate with the PHON values through the formal device known as **named disjunction** (Krieger and Nerbonne 1991). Named disjunctions are disunctive lists of elements enclosed in brackets and separated by a slash. An element of a named disjunction can, in its turn, be a (named) disjunctive list. A name is separated by its list through a dash:

$(\text{element}_1/\text{element}_2/.../\text{element}_n)\text{-list\_name}$

The elements of two identically named disjunctions (e.g. '-alt') are made covary in their respective order. Accordingly, *sces-* is associated with either 'stem_index' *r4* or *r6*, *scend-* with any element of the disjunctive list '(r1; r2; r3; r5)', where ';' is the OR operator. Stem indices are also referred to their relevant inflectional endings through covariation with the values of 'paradigm_class', which defines the set of appropriate inflectional endings, and corresponds roughly to the notion of conjugation class.

A paradigmatic schema is encoded as a complex entry of type "inflectional ending" whose PHON contains a disjunctive list of paradigmatically-related endings. This is done by using the macro below, which takes one more argument than the macro m_ROOT_WS1 does, namely HEAD, specified for category, agreement and tense-mood information.

```
macro( m_ENDING_WS[LEX,PHON,INFLEX,HEAD],
      ld:{spec=>specif:{proc_type=>proc_type:{tlm=>n,
                                              process=>y},
                        data_type=>lex:{lex_id=>LEX}},
          sign=>sign:{phon=>[PHON],
                      constype=>morpheme:{
                        morphtype=>i_ending:{inflex=>INFLEX}},
                      synsem=>synsem:{
                        local=>local:{
                          syn=>syn:{
                            cat=>head_cat:{
                              head=>HEAD}}}}}}).
```

Unlike in m_ROOT_WS1, LEX is not a lexeme, but a particular tense-mood specification; e.g. present indicative in the example below:

```
v_present_indicative_0 ~
  m_ENDING_WS[
    l_v_present_indicative_0,
     ((o/i/(a/e/o)-tv)-pers/
      (iamo/(ato/ete/ite)-tv/(ano/ono/ono)-tv)-pers)-num,
     inflex:{inflex_class=>[v,(a/o/i)-tv],
             paradigm_class=>zero,
             stem_index=>((r2/r3/r3)-pers/(r1/r1/r2)-pers)-num,
             block=>((pri&'1s'/pri&'2s'/pri&'3s')-pers/
                     (pri&'1p'/pri&'2p'/pri&'3p')-pers)-num},
     v_finite_head:{infl=>agroom_index:{pers=>(p1/p2/p3)-pers,
                                        numb=>(sing/plur)-num,
                                        tense=>pres,
                                        mood=>ind}}].
```

Stem indices correlate with the set of inflectional endings (for the present indicative of 'paradigm_class' zero) with which they can occur. The INFLEX argument contains, besides paradigm class and paradigm schema information, the feature 'block', whose main purpose is to stop defective verbs from being inflected for particular paradigm cells.

In compliance with GIC, the same paradigmatic schema is used for capturing distributional redundancies in the selection of alternating as well as non alternating stems. For example, the entry of the regular verb *amare* below is made unify with the paradigmatic schema above through WFR, with no further readjustment: its unique stem *am-*, left lexically unspecified for paradigmatic indexing, unifies with any index.

```
amare ~
  m_ROOT_WS1[l_amare,
       am,
       inflex:{inflex_class=>[v,a],
               paradigm_class=>zero}].
```

5 The Italian Paradigm Schema

	present indicative	imperfect indicative	past indicative
1s	r2	r1	r4
2s	r3	r1	r1
3s	r3	r1	r4
1p	r1	r1	r1
2p	r1	r1	r1
3p	r2	r1	r4

	future indicative	present subjunctive	imperfect subjunctive
1s	r5	r2	r1
2s	r5	r2	r1
3s	r5	r2	r1
1p	r5	r1	r1
2p	r5	r1	r1
3p	r5	r2	r1

present gerund	present infinitive	present participle	past participle
r1	r1	r1	r6

	present conditional	present imperative
1s	r5	-
2s	r5	r3
3s	r5	r2
1p	r5	r1
2p	r5	r1
3p	r5	r2

The schema above works with a fully expanded version of GIC, where default indexing for alternants *r4-r6* are conveniently stipulated. The schema accounts for all regular Italian verbs of any conjugation class, and for the vast majority of Italian irregular basic and inchoative verbs, approximately 450 lexemes.

In the end, it fails to account for 4 irregular verbs of the first conjugation class (namely *andare*, *dare*, *fare*, *stare*) only, and six irregular verbs of the second and third conjugation (*avere*,

essere, *dovere*, *potere*, *sapere*, *dire*). These outstanding exceptions can be captured either by adjusting the existing paradigmatic schema, or through further stipulation of an ad hoc schema. The latter being a fairly trivial strategy, here we concentrate on the former only, which requires use of no other formal device.

All ten outstanding exceptions share the property of conforming to the paradigmatic schema above only partially. A good example is the present indicative of DOVERE ('must'):

dev	*o*	"*I must*"	
dev	*i*	"*you must*"	
dev	*e*	"(*s*)*he must*"	(1)
dobb	*iamo*	"*we must*"	
dov	*ete*	"*you must*"	
dev	*ono*	"*they must*"	

1s	r2
2s	r3
3s	r3
1p	r1
2p	r1
3p	r2

The paradigm departs from the paradigmatic schema of present indicative (repeated here for convenience in grid 1) in two respects: first, the missing *r3* alternant is replaced by *r2*, not by *r1*. Moreover *r1* takes the cell of the second-person plural only, while the cell of first-person plural being filled in by the further alternant *dobb-*. This can be captured through the following (simplified) lexical entry of DOVERE:

```
dovere :
  m_ROOT_WS1[] dovere,
      (dov/dobb/dev)-alt,
      inflex-{inflex_class=>[v,ol],
              paradigm_class=>zero,
              stem_index=>(r1/r1/(r2;r3))-alt,
              block=>((~pri&'1p')/pri&'1p'/_)-alt}]
```

where both *dov-* and *dobb-* are assigned the same stem index *r1* but are prevented from being assigned the same paradigmatic cells thanks to the feature 'block'. *Dov-* is associated with the 'block' value **NOT** PRESENT INDICATIVE **AND** FIRST PLURAL (~pri&'1p'), meaning that *dov-* is blocked from showing up in that cell. In its turn, *dobb-* takes the 'block' value PRESENT INDICATIVE **AND** FIRST PLURAL, which means that it is allowed to occur in that cell only. Accordingly the ungrammatical strings **doviamo* and **dobbete* are ruled out, due to the clash, in WFR, between the values of 'block' specified in the lexeme entry and the corresponding values of an inflectional ending.

6 Discussion

Krieger and Nerbonne (1991) illustrate an approach to inflection whereby paradigms are modelled as abstract entries of type "word", containing disjunctive lists of inflectional endings which are made covary in parallel with the relevant agreement feature values, and trailed after a (underspecified) stem in the PHON attribute. Accordingly, a paradigm is viewed as a node in a lexical hierarchy, whose leaves are the particular lexical entries which inherit the paradigm of their mother node. Moreover, no paradigmatic schema is resorted to. However conceptually neat, this approach is not implementable in a monotonic formalism such as ALEP, where default inheritance and overriding are not supported. In our approach, a verb paradigm is produced as the result of combining a set of indexed stems with an appropriate class of inflectional endings through a single paradigmatic schema. The paradigmatic schema is not an abstract node in a hierarchical lexicon, but a (named) disjunctive list of fully-specified entries of type "inflectional ending", each competing with the others for one or more specific cell(s) in the paradigm. The approach makes it possible to cluster verbs in comparatively few, highly natural linguistic classes, showing different patterns of stem indexing, with a comparatively scanty repertoire of formal means (no nonmonotic operations being resorted to). Among other things, it simplifies lexical encoding considerably: the creation of a new paradigm does not require introduction of a new node in a lexical hierarchy, with possible rearrangement of lower nodes, but simple addition of a new set of concretely-specified entries.

This approach compares favourably with a syntagmatic Two-Level Morphology (TLM) treatment of paradigmatic stem alternants seen as instances of phonologically conditioned suppletion. In Italian a single paradigmatic schema (which accounts, together with GIC, for all regular verbs and for 450 out of 460 irregular verbs) does the job of a number of TLM rules mapping paradigmatic allomorphs onto abstract stems. Notably, not all stem alternants need be indexed in the lexicon. Some of them, referred to as **syntagmatic stem alternants** in the literature (Stump 1995), are treated as genuine instances of phonologically conditioned suppletion, and thus taken care of by a separate Two-Level component. Syntagmatic stem alternants which, unlike paradigmatic ones, occur in Italian with both regular and irregular verbs, are not considered further here.

Finally, it is worth noting that the proposed paradigmatic approach works in generation as well as in analysis at no additional computational cost, thus providing a nice case of a successful blending of descriptive economy and declarativity.

7 Improvements and conclusion

GIC makes reference to positional values in the paradigm only, so that stem alternants are indexed relative to paradigmatic cells (e.g. second-person singular of present indicative), not to inherent formal properties either of theirs or of their

inflectional endings, in keeping with IAH. In the current implementation, all stem alternants of a certain verb are indexed, within the relevant lexical entry, *in praesentia*, that is through full listing, so we miss the generalization that the same type of stem alternation takes place in more than one entry (say both in VENIRE and TENERE). Certainly, a more highly valued lexicon should also be able to capture this redundancy. Within the approach suggested here, an easily imagined solution is that the lexical value of redundant stem alternants is abstracted away from any such redundant properties, which are stored in a separate "meta-entry". Full lexical entries are then cranked out through unification of these separate pieces of information, a root alternant such as *veng-* being thus produced through concatenation of *v-* and *-eng-*. However simple, this solution is impossible to implement in ALEP, where a string undergoing lexicon look-up is always an atom (as opposed to a list). With a parsimonious use of formal means, it can nonetheless be implemented in Evans and Gazdar's DATR quite straightforwardly (Evans and Gazdar 1990, 1995).

By way of conclusion, our experience shows that: i) the inflectional morphology of Italian is an inventory of both internally- and externally-related paradigms rather than an inventory of unrelated morphemes; ii) paradigms define highly natural inflecting classes; iii) if looked at at an appropriate level of abstraction, they exhibit a strikingly uniform and simple underlying pattern of stem distribution: the paradigmatic schema; iv) a paradigmatic schema is declarative, and works well in both word analysis and generation; it relies on a minimum of word structure rule stipulation; v) it allows for a considerable level of descriptive economy: in Italian a single schema (in combination with GIC) is found to hold for all regular verbs, and for 450 out of 460 irregular verbs; vi) it can be ignored only at the fairly high price of writing a good many ad hoc readjustment rules; vii) finally, it is not computationally greedy; it can be implemented even in lean monotonic frameworks such as ALEP.

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