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Allomorphy in OT: the Italian mobile diphthongs*

Geert Booij (Leiden University)
Bart van der Veer (Antwerpen)

1 Introduction

Allomorphy can be defined as the complementary distribution of morphemes with the same meaning. The traditional approach to allomorphy in generative phonology can be characterized as follows. Allomorphy is accounted for as much as possible in terms of a common underlying form for the relevant allomorphs, in combination with a set of phonological rules that derive these allomorphs as surface forms in different contexts.

This approach to allomorphy has been successful in cases of regular allomorphy where productive phonological rules can be invoked to derive the surface forms of a morpheme. However, there are many cases in which the allomorphs do not bear enough phonological similarity to even consider seriously the possibility that the allomorphs can be derived from a common underlying form. This kind of allomorphy is referred to as 'lexical allomorphy' or 'suppletive allomorphy', and it is usually assumed that such allomorphy must be accounted for by listing each of the allomorphs in the lexicon.

In some cases of lexical allomorphy, the selection of the right allomorph is a matter of morphology proper. This is, for instance, the case for competing suffixes from different strata of the Dutch lexicon: the native suffix *-heid* '-hood' can be attached to both native and non-native stems, whereas the synonymous suffix *-iteit* '-ity' can be attached to non-native stems only. In such cases, there is no phonology whatsoever involved in allomorph selection.

As pointed out in Carstairs (1988), the fact that allomorphs cannot be derived from a single underlying form and must be stored lexically does not necessarily imply that the choice between the allomorphs has nothing to do with phonology. There are lots of cases in which the choice of a particular allomorph makes sense from a phonological point of view, and appears to have a phonological motivation. Carstairs qualifies such cases as 'phonologically conditioned suppletion'.

An example of suppletive allomorphy in Dutch, discussed in detail in Booij (1998), is the competition between two plural suffixes, *-s* and *-en*, which are – with some exceptions - in complementary distribution, but for which there is obviously no common underlying phonological form. What can be shown, however, is that the selection of the correct allomorph is governed by phonological constraints. The basic generalization is that the suffix *-en* [ən] occurs when the stem of the noun ends in stressed syllable, whereas *-s* appears after an unstressed syllable. The effect of this distribution is that plural nouns always end in a disyllabic trochee, the optimal prosodic foot of Dutch. This is illustrated by the following examples:

(1)

singular form	*plural form*
kánon ‘canon’	kánon-s
kanón ‘gun’	kanónn-en
nátie ‘nation’	nátie-s
geníe ‘genius’	geníe-en

This selection principle also predicts correctly – again, with some exceptions – that the plural forms of monosyllabic nouns require the plural suffix *-en*:

(2)

non ‘nun’	nonn-en
knie ‘knee’	knie-en
bal ‘ball’	ball-en

It is possible to account for this selection principle by assuming two morphological rules for the formation of plural nouns in Dutch, in which the phonological conditions for the selection of these plural suffixes are stated. Such an account, however, does not explain why this particular distribution of these allomorphs is found. The inverse situation, in which the suffix *-s* is added after a stressed syllable, and the suffix *-en* after an unstressed one, would be equally simple in terms of descriptive costs. What a rule-based analysis cannot express is the motivating force behind this distributional pattern, the tendency for an optimal prosodic shape of words. This can be expressed, however, in a theory that makes use of output constraints. Optimality Theory is such a theory.

In this article we will focus on a famous case of allomorphy in Italian, the phenomenon of the so called mobile diphthongs, a vowel alternation in the roots of inflectionally or derivationally related words. We will argue that this alternation is a case in which the two allomorphs have to be lexically listed, and hence is a case of lexical allomorphy. However, the selection of the right allomorph is performed by the language-specific ranking of a set of universal phonological constraints. This analysis follows the line of analysis as developed in Rubach and Booij (2001) for Polish, and in similar analyses listed in McCarthy (2002: 183). It is mainly based on work reported in the dissertation of the second author (Van der Veer 2006).

In section 2, we will argue why we cannot account for this alternation by assuming a common underlying form. Instead, an OT- account will be presented, and the advantages of such an account will be highlighted. In section 3 we will show that there is independent external evidence for this approach: the facts of analogical levelling require that inflected and derived words with a particular allomorph are stored in the lexicon. That is, this allomorphy must be lexical in nature. Section 4 will provide a summary of our findings.

2 Mobile diphthongs in Italian: an OT analysis

The ‘mobile diphthong rule’ refers to the alternation pattern of the stressed diphthongs [jɛ] and [wɔ] vs the unstressed corresponding monophthongs [e] and [o]. This alternation

plays a role in the inflection of a number of verbs (see 3) as well as some derivational processes (including diminutivization) (see 4).

(3)

siedo	['sjɛdo]	'I sit'	sederò	[sede'ro]	'I shall sit'
vieni	['vjɛni]	'you come'	veniamo	[ve'njamo]	'we come'
muovo	['mwɔvo]	'I move'	moviamo	[mo'vjamo]	'we move'
suono	['swɔno]	'I play'	soniamo	[so'njamo]	'we play'

(4)

dieci	['djɛtʃi]	'ten'	decina	[de't͡ʃiːna]	'ten or so'
muovo	['mwɔvo]	'I move'	movimento	[movi'mento]	'movement'
uomo	['wɔmo]	'man'	omino	[o'miːno]	'little man'

In the phonological literature that has appeared on this topic, this alternation pattern has been analysed as a case of allomorphy in which the allomorphs are distributed according to phonological generalizations. Sluyters (1992) relates the alternation to stressed open syllable diphthongization. He argues that the mobile diphthongs are the result of a synchronic diphthongization rule, which is closely related to a rule that lengthens vowels: both phonological processes have the stressed open syllable as their domain of application and are aimed at creating well-formed binary feet. Conversely, Saltarelli (1970) invokes a monophthongization rule. He accounts for the monophthong–diphthong alternation by adopting the underlying diphthongs /iɛː/ and /uɔː/, from which simplex vowels are derived by means of a monophthongization rule. This rule applies after a rule which turns high vowels into glides when they are adjacent to a vowel.

Both Saltarelli and Sluyters analyse the monophthong–diphthong alternation as a synchronically productive phenomenon in Italian grammar. However, this synchronic approach is problematic, since it predicts the occurrence of diphthongization or monophthongization in cases where this is not correct. For instance, in a number of Italian verbs there is no monophthong–diphthong alternation at all: either the mid vowel or the diphthong is maintained throughout the paradigm. Examples of such verbs are given in (5).

(5)

spiegare	'to explain'	coprire	'to cover'
chiedere	'to ask'	levare	'to lift'
nuotare	'to swim'	notare	'to note'
vuotare	'to empty'	votare	'to vote'
abbuonare	'to forgive'	abbonare	'to subscribe'

Thus, the indicative present of the verbs *spiegare* and *coprire* is as follows:

(6)				
	SG	1	spiego	copro
		2	spieghi	copri
		3	spiega	copre
	PL	1	spieghiamo	copriamo
		2	spiegate	coprite
		3	spiegono	coprono

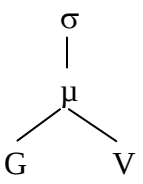
According to Sluyters' theory, we would expect the second person singular of the present indicative of the verb *coprire* 'to cover' to be **cuòpri*: the stressed mid-vowel diphthongizes in order to create a heavy stressed syllable. Likewise, Saltarelli's theory predicts that the second person plural of the present indicative of the verb *spiegare* 'to explain' is **spegàte*, in which the diphthong monophthongizes in unstressed position. The forms **cuopri* and **spegate* are not attested in modern Italian. Interestingly, in early Italian texts we do find forms such as *cuopro*, *cuopri*, *cuopre*, which suggests that stressed open syllable diphthongization may once have been a productive process in the language but no longer is. An analysis of the Italian monophthong– diphthong alternation in terms of phonological allomorphy, deriving the allomorphs from a single underlying representation, cannot differentiate between alternating and non-alternating vowels and diphthongs and would have to allow for many lexical exceptions.[1]

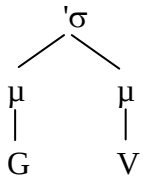
An alternative to positing a single underlying representation is to follow Rubach and Booij's (2001) analysis of Polish iotation and list the allomorphs in the lexicon. Rubach and Booij argue that this strategy does not imply that there is no task for phonology: the allomorphs may be arbitrary, but their distribution is regulated by the ranking of universal constraints. The listing requires that we posit multiple stems for each morpheme, so, for instance, the verb *sedere* would have two underlying allomorphs: /sɛd/ and /sjɛd/. Following the authors, the selection of either /sɛd/ or /sjɛd/ is predicted by the interaction of faithfulness and markedness constraints, as will be demonstrated in the remainder of this section.

As a preliminary, let us note that there is evidence that Italian onglides belong to the nucleus. Rising diphthongs have an autonomous phonological status since they occur after all kinds of consonants, as illustrated by the following examples:

(7)						
	[je]	piegare	'to fold'	[wi]	guida	'guide'
	[jɛ]	fieno	'hay'	[we]	quercia	'oak'
	[ja]	bianco	'white'	[wɛ]	guerra	'war'
	[jɔ]	pioggia	'rain'	[wa]	punt[wa]lità	'punctuality'
	[jo]	tempio	'temple'	[wɔ]	cuore	'heart'
	[ju]	fiume	'river'	[wo]	vuotare	'to empty'

Furthermore, acoustic experiments have shown that the duration of onglides interacts with the duration of the following vowel: the duration of the whole diphthong increases in stressed position (see van der Veer 2006). Therefore we assume that rising diphthongs are monomoraic in unstressed syllables and bimoraic in stressed (open) syllables, see (8).

(8) (a) 

(b) 

Now suppose we assume two underlying allomorphs for the root of the verb *sedere*: /sɛd/ and /sjɛd/. Subsequently, we would have to establish the constraint ranking responsible for the following alternation pattern:

(9) *sedere*, present indicative

SG	1	s[jɛ]do
	2	s[jɛ]di
	3	s[jɛ]de
PL	1	s[e]diamo
	2	s[e]dete
	3	s[jɛ]dono

In our OT analysis we use a metrical constraint $'\sigma_{\mu\mu}$ ('bimoraic syllables are stressed; stressed syllables are bimoraic')[2] and a faithfulness constraint DEP-μ ('no epenthesis'). The interaction of these two constraints is responsible for the distribution of long and short vowels and diphthongs in Italian. as is illustrated in the following (simplified) tableaux for *casa* 'house' and *piano* 'flat', in which $'\sigma_{\mu\mu}$ dominates DEP-μ:

(10)

Input: /kasa/		$'\sigma_{\mu\mu}$	DEP-μ
a. ☞	'kaː.sa		*
b.	'ka.sa	*!	

(11)

Input: /pjano/		$'\sigma_{\mu\mu}$	DEP-μ
a. ☞	'pj$_{\mu}$a$_{\mu}$.no		*
b.	'pja$_{\mu}$.no	*!	

If we construct a tableau in the Rubach and Booij style, i.e. with two underlying allomorphs, we must conclude that the ranking $'\sigma_{\mu\mu}$ » DEP-μ cannot determine which of the output candidates is optimal:[3]

(12a)

/sɛd/ /sjɛd/ } + i		'σμμ	DEP-μ
a.	☞ 'sɛː.di		*
b.	☞ 'sj$_{\mu}$ɛ$_{\mu}$.di		*
c.	'sɛ.di	*	

(12b)

/sɛd/ /sjɛd/ } + ete		'σμμ	DEP-μ
a.	☞ se.'deː.te		
b.	☞ sje$_{\mu}$.'deː.te		
c.	sj$_{\mu}$e$_{\mu}$.'deː.te		*

Candidates with light stressed syllables are ruled out immediately by 'σ$_{\mu\mu}$. Since both vowels and rising diphthongs can surface as either short or long, the constraint ranking in (12) does not suffice to select the correct output. In (12a) both candidates violate the faithfulness constraint, because both contain a mora which has no correspondent in the input. In (12b) no violation is incurred by either of the candidates. Therefore, the alternation pattern cannot be dealt with without additional constraints.

The key to the solution lies in the shape of the syllabic nuclei. The candidates in (12) exhibit the complete inventory of possible syllabic nuclei: (a) short vowels, (b) long vowels, (c) monomoraic diphthongs, and (d) bimoraic diphthongs. All languages have short vowels, but the occurrence of type b, c and d is dictated by markedness constraints on syllable structure. The following two constraints are crucial in the current analysis:

(13) (a) *N$_{\mu\mu}$
No branching between a syllable nucleus and two moras.

(b) m ↔ μ
No branching between melody and mora.

Both anti-branching constraints militate complex nuclei, in the spirit of *COMPLEX-ONSET and *COMPLEX-CODA. Note that (13b) could be split up in a constraint against a more branching into two melodies (e.g. a glide-vowel combination) and one against a melody (e.g. a vowel)spreading over more than one mora. In general, one-to-one correspondences are preferred over branching within the syllable nucleus. The difference between the two constraints in (13) is where the branching and the one-two-one correspondence are located: either between syllable nucleus and mora, or between mora and melody. In the table below we summarize the violation types incurred by all four syllabic nuclei that occur in Italian:

(14)

	$*N_{\mu\mu}$	$m \leftrightarrow \mu$
$V_{\mu\mu}$	*	*
$G_{\mu}V_{\mu}$	*	
GV_{μ}		*
V		

From tableau (14) we can conclude that $V_{\mu\mu}$ is doubly bad since it has a branching syllable node and a branching melody, and therefore it violates $*N_{\mu\mu}$ and $m \leftrightarrow \mu$.

We assume that within the syllable nucleus, branching violations at a higher level are more serious than branching violations at a lower level, and therefore propose that $*N_{\mu\mu}$ is ranked higher than $m \leftrightarrow \mu$. The tableaux in (15) demonstrate how the proposed constraint ranking selects the optimal candidates in our case of allomorphy:

(15a)

/sɛd/ /sjɛd/ } + i	$*N_{\mu\mu}$	$m \leftrightarrow \mu$
a. 'sɛː.di	*!	*
b. ☞ 'sj$_{\mu}$ɛ$_{\mu}$.di	*	

(15b)

/sɛd/ /sjɛd/ } + ete	$*N_{\mu\mu}$	$m \leftrightarrow \mu$
a. ☞ se.'deː.te		
b. sje$_{\mu}$.'deː.te[4]		*!

Candidate (a) in (15a) loses as it violates both constraints. In (15b) the candidate with the short vowel wins, because in unstressed syllables a short vowel is always the most optimal syllable nucleus. The point of interest is that stressed long vowels and unstressed monomoraic diphthongs are perfectly acceptable syllabic nuclei in Italian. In cases where these types of nuclei surface, the underlying representations do not parallel those of cases with different underlying allomorphs (as in 15). For instance, the verb *coprire* 'to cover' only has /kɔpr/ as its underlying form and a high-ranked faithfulness constraint DEP_{seg} ('no epenthesis') prevents the stressed nucleus from surfacing as a bimoraic diphthong by glide insertion, as shown in (16):

(16)

/kɔpr/ + i	DEP_{seg}	$*N_{\mu\mu}$
a. ☞ 'kɔː.pri		*
b. 'kw$_{\mu}$ɔ$_{\mu}$.pri	*!	*

Conversely, the bimoraic diphthong in candidate (2) in (15a) is not an instance of glide insertion, because the glide is present in the /sjɛd/ allomorph and therefore DEP_{seg} is not violated, as can be seen in the following tableau:

(17)

/sɛd/ /sjɛd/ } + i	DEP_{seg}	* $N_{\mu\mu}$	m ↔ μ
a. 'sɛː.di		*!	*
b. ☞ 'sj$_{\mu}$ɛ$_{\mu}$.di			*

Similarly, monomoraic diphthongs surface because of high-ranked MAX_{seg} ('no deletion'). The tableau in (18) evaluates the second person plural of the present indicative of *spiegare* 'to explain':

(18)

/spjɛg/ + ate	MAX_{seg}	m ↔ μ
a. spje.'gaː.te	*!	
b. ☞ spje$_{\mu}$.'gaː.te		

Candidate (18a) fatally violates MAX_{seg}, because the input glide is deleted. The verb *spiegare* has only one input /spjɛg/, as opposed to *sedere*. In (19) the tableau for the second person plural of *sedere* is presented once more, this time including the relevant faithfulness constraint. Since the input contains an allomorph without a glide, the winning candidate does not violate MAX_{seg}.

(19)

/sɛd/ /sjɛd/ } + ete	MAX_{seg}	m ↔ μ
a. ☞ se.'deː.te		
b. sje$_{\mu}$.'deː.te		*!

The 'multi-input' analysis developed here has some major advantages with respect to the 'mono-input' analyses of Sluyters (1992) and Saltarelli (1970), who claimed that the monophthong–diphthong alternation was triggered by a diphthongization or monophthongization rule, respectively. Mono-input approaches to the monophthong–diphthong alternation suffer from overapplication effects – diphthongs or monophthongs occur where they should not. They rely on arbitrary and language-specific rules. In multi-input theories of allomorphy, the underlying allomorphs are arbitrary, but their distribution is governed by a language-specific ranking of universal constraints. The conclusion is that the monophthong–diphthong alternation is not a phenomenon triggered by active phonological processes but an instance of mixed phonological and morphological allomorphy: the allomorphs are posited in the input and the constraint ranking predicts where these allomorphs will appear.

Another advantage is that the newly proposed analysis also works for other alternation patterns in Modern Italian. For instance, velar palatalization, i.e. the

palatalization of a velar sound in the context of a following high front vowel, has typically been considered as a readjustment phenomenon triggered by phonological factors (cf. Scalise 1984). It characterizes the flexion and derivation of a number of words, as in the following examples:

(20)	amì[k]o	'friend'	amì[tʃ]i	'friends'
	bèl[g]a	'Belgian'	bèl[dʒ]i	'Belgians'
	cattòli[k]o	'catholic	cattoli[tʃ]ìssimo	'very catholic'
	stòri[k]o	'historian'	stòri[tʃ]i	'historians'

However, velar palatalization is not a generalized phenomenon in Italian, so it is not possible to interpret the [k]/[tʃ] and [g]/[dʒ] alternations as instances of exclusively phonological allomorphy (see Celata and Bertinetto 2005). Such an explanation would have to deal with too many lexical exceptions, as exemplified below:

(21)	grè[k]o	'Greek'	grè[tʃ]i	'Greeks'
	còmi[k]o	'comedian'	còmi[tʃ]i	'comedians'
	bèl[g]a	'Belgian'	bèl[dʒ]i	'Belgians'
		as opposed to:		
	tùr[k]o	'Turkish'	tùr[k]i	'Turks'
	càrico	'freight'	càri[k]i	'freights'
	collè[g]a	'colleague'	collè[g]i	'colleagues'

Since it seems impossible to derive palatalization effects from a single underlying representation, an effective alternative is to list the allomorphs in the input. For instance, the underlying allomorphs of *greco* are /grEk/ and /grEtʃ/, whereas *turco* has only one input morpheme /turk/. Assuming a constraint PAL, which requires consonants to palatalize when they precede front vowels (cf. Łubowicz 2002), it is clear that PAL is dominated by IDENT(Place), a faithfulness constraint that calls for correspondents in input and output to have identical place features. Such a ranking blocks palatalization, as illustrated in the tableau for *turchi,* the plural of *turco*:

(22)

/turk/ + i	ID(Place)	PAL
a. ☞ 'tur.ki		*
b. 'tur.tʃi	*!	

The ranking in (22) will yield a different output when the input consists of multiple allomorphs, as in the following tableau for *greci*, the plural of *greco*. Here, the palatalized output will win, since it does not violate the faithfulness constraint.[5]

(23)

grɛk / grɛtʃ } + i	ID(Place)	PAL
a. 'grɛː.ki		*!
b. ☞ 'grɛː.tʃi		

The current approach can be elegantly related to one of the key consequences of Optimality Theory, called 'the emergence of the unmarked' (McCarthy and Prince 1994). Consider the singular form *greco*: the constraint ranking in (23) does not prohibit the allomorph /grɛtʃ/ from surfacing before a back vowel and evaluates the candidates ['grɛɔ.ko] and ['grɛɔ.tʃo] as equally optimal. Rubach and Booij (2001) propose to solve this dilemma with the help of markedness constraints. In this case, it can be argued – in the spirit of Prince and Smolensky (1993/2002) – that /tʃ/ is a more marked and cross-linguistically less frequent segment than /k/, resulting in the ranking *tʃ » *k. The role that markedness constraints play in selecting the unmarked allomorph is demonstrated in the following tableau:

(24)

grɛk / grɛtʃ } + o	ID(Place)	PAL	*tʃ	*k
a. ☞ 'grɛː.ko				*
b. 'grɛː.tʃo			*!	

A final advantage of the multi-input approach is that it makes an extremely interesting diachronic prediction. It was argued that irregular, non-productive alternations are lexicalized. As a consequence, the lexicon is more complex than in an approach that derives the allomorphs from one single input. This entails a substantially increased memorization burden on the speaker. When memory fails and analogical speech errors are produced, it is expected that errors of this kind – i.e. regularizations of non-productive alternations – are more easily accepted than forms that result from regularizations of productive alternations (cf. Wetzels 1981). This concept of analogical change is pursued in the next section.

3 Independent evidence for the lexical representation of allomorphy: analogical change

The monophthong–diphthong alternation, "just like all other alternations, represents a redundancy for the language" (Tekavčić 1972: 345, the translation is ours). In fact, written sources and experiments (Van der Veer 2001, 2006) provide evidence that this alternation is subject to a great degree of analogical levelling. In numerous cases the diphthongs are reported to have extended to unstressed syllables, as illustrated in (25).

(25) s[je]deró ‘I shall sit’
p[je]díno ‘small foot’
m[wo]viámo ‘we move’
b[wo]níno ‘rather good’

The elimination of morphophonemic alternations, also referred to as analogical levelling, under the pressure of paradigm uniformity, is a fairly common phenomenon in the world’s languages. Some salient observations about analogical change are made by Wetzels (1981). The central idea of this dissertation, couched in the SPE framework, is that opaque alternations are lexicalized by the speaker and, since they constitute an awkward allomorphy for the speaker, are subject to elimination (see also Kiparsky 1982).

There is good evidence that the ‘mobile diphthong rule’ had become opaque. Since the 10th/11th century, surface exceptions had been brought about by other changes in the language, such as the palatalization of post-consonantal /l/, the elimination of the onglides [j] and [w] after consonant clusters ending in /r/ or the introduction of loanwords, mostly latinisms (voci dotte):

(26) Sources of opacity of the ‘mobile diphthong rule’

- palatalization of /l/ in the consonant clusters /pl/, /bl/, /kl/, /gl/ and /fl/ (10th/11th century, cf. Castellani 1976)
  sp[jɛ]go ~ sp[je]ghiàmo ‘I explain, we explain’ (cf. Latin explico ‘I unfold’)
  p[jɛ]no ~ p[je]nézza ‘full, fullness’ (cf. Latin pleːnus ‘full’)

- deletion of [j] and [w] after consonant clusters ending in /r/ (14th/15th century, cf. Castellani 1967)
  pr[jɛ]go > pr[ɛ]go ~ pr[e]ghiàmo ‘I beg, we beg’
  tr[wɔ]va > tr[ɔː]va ~ tr[o]viàmo ‘he finds, we find’
  pr[wɔ]va > pr[ɔː]va ~ pr[o]viàmo ‘he tries, we try’

- deletion of [w] after the palatal consonants /j/, /ʎ/, /ɲ/, /ʃ/, /tʃ/ and /dʒ/ (19th century, cf. Migliorini 1963)
  [dʒwɔ]ca > [dʒɔː]ca ~ [dʒo]chiàmo ‘to play’
  tova[ʎʎwɔ]lo > tova[ʎʎɔ]lo ~ tova[ʎʎo]lìno ‘napkin, small napkin’

- loanwords
  rip[ɛː]to ~ rip[e]tiàmo ‘I repeat, we repeat’

In (27) we summarize the history of the monophthong–diphthong alternation:

(27) History of the monophthong–diphthong alternation

	output (stressed~unstr.)	*input*
stage 1	mɔːv-~mov-	mɔv-
stage 2	mɔəv-~mov-	mɔv-
stage 3	muəv-~mov-	mɔv-
stage 4	mwɔv-~mov-	mɔv-
stage 5	mwɔv-~mov-	mɔv-/ mwɔv-
stage 6	mwɔv-~mov-/mwov-	mɔv-/ mwɔv-
(stage 7)	mwɔv-~mwov-	mwɔv-

Stage 1 reflects the pre-diphthongization stage in late spoken Latin; stressed open syllable diphthongization is assumed to have taken place in subsequent stages (stages 2-4) (cf. Sánchez Miret 1998). In stage 5, the diphthongization process became opaque and multiple inputs are posited. Stage 6 is a variation stage in which more and more speakers started to eliminate the alternation, extending the diphthong to the unstressed syllables; this levelling is almost complete, although back vowels/diphthongs are slightly more resistant to the change. Complete levelling of the monophthong–diphthong alternation is reached in (hypothetical) stage 7. Conversely, the alternation between stressed mid-low vowels and unstressed mid-high vowels persists, because in Italian the mid vowels are neutralized in unstressed syllables. Therefore, the allophonic alternation between [jɛ, wɔ] and [je, wo] is predictable and persists.

It is clear that, as Van de Weijer (1999: 148) observes, "analogical change touches on many different aspects of grammar: phonology, morphology and the (re–)re-presentation of lexical items." Recently, paradigm effects have received considerable attention in linguistics, for instance in Downing, Hall and Raffelsiefen (eds., 2005). These theories face the daunting challenge of covering the various aspects of paradigm effects and analogical change. In discussing the levelling effects concerning the mobile diphthongs, we will follow Albright and Hayes (2002) and Albright (2002, 2004, 2005*a,b*) and argue that access to allomorphy depends on access to lexically listed information in inflected and derived words. This point is also made in Celata and Bertinetto (2005) for Italian velar palatalization.

3.1 Paradigms and their bases

Albright and Hayes (2002) claim that language learners compare all the available paradigms and select the base form that allows to construct the remaining members of the paradigm as reliably and efficiently as possible. They present a computational model of base discovery, which has been applied to a number of languages (e.g. Albright 2002, 2004, 2005*a,b*). Given paradigms of related words, the model learns the morphological and phonological rules needed to derive the entire paradigm from one single base form. In this section we use hypothetical language data to illustrate the premises of the model and construct a subgrammar of consonant alternation in nouns. Consider the following hypothetical language:

(28) Hypothetical language (stage 1)

SG	PL
pan	pani
tap	tapi
kam	kami
pa**k**	pa**k**i
ra**k**	ra**g**i
ma**t**	ma**tʃ**i
pa**t**	pa**tʃ**i

In this language, phonology acts to neutralize the contrast between voiced /g/ and voiceless /k/: the contrast is present in plural nouns before the plural ending *-i*, but neutralized in word-final position in singular nouns, where we find only [k]. These data suggest that the language has a process of final velar devoicing. The language learner can discover this process (i) by comparing the singular (*rak*) with the plural (*ragi*) and (ii) by comparing *rak ~ ragi* with *pak ~ paki*. This second comparison is necessary to discover the direction of the process, which, in fact, is a process of final devoicing and not of prevocalic voicing, otherwise we would expect the plural of *pak* to be *pagi*. Since the neutralization affects the singular forms, the mapping from the singular to the plural is unpredictable. Therefore it is unlikely that the learner would memorize just the singular, since he would need two rules to project the plural ([k] → [ki] and [k] → [gi]) which would only have 50 percent accuracy in the form sets presented in (28). If, on the other hand, the learner were to derive the singular from the plural, he would still need two rules ([ki] → [k] and [gi] → [k]), but each of the rules would have 100 percent accuracy in the lexicon. Suppose the learner were confronted with a hypothetical new plural form *bagi*, he would, with 100 percent certainty, derive the correct form for the singular: *bak*.

The data further suggest that the language has a process of coronal palatalization, [t] becoming [tʃ] before the plural ending *-i*. To capture this process, the language learner will set up a morphological rule [tʃi]→ [t], i.e. taking the plural form as the base, as he does for the cases of devoicing.

Albright and Hayes' base discovery model or algorithm assesses the reliability of these types of morphological rule and tries to find generalizations that have as few exceptions as possible. For more detailed analyses of real language data, the reader is referred to work by Albright, cited above. Not only does their model show that paradigms (including inflectional paradigms) are constructed around bases, it also claims to make correct predictions about the direction of analogical change. To illustrate this, let us assume that the hypothetical language considered so far reaches a new stage in which we encounter the following noun paradigms:

(29) Hypothetical language (stage 2)

SG	PL
ma**t**	ma**tʃ**i
ki**tʃ**	ki**tʃ**i
po**t**	po**t**i

Apparently, the process of coronal palatalization has been obscured by other generalizations and has become opaque. Now we find [t] in contexts where we would have expected [tʃ]. Besides, the morphological rule [tʃi] → [t], set up in a previous stage, has no longer 100 percent accuracy. As a result of the changes, contrasts are no longer more faithfully preserved in the plural. In such cases, Albright (2005*b*) proposes that the learner is forced to choose a single form that is generally most predictive: since the plural is most informative about other contrasts in the language (e.g. the contrast between [k] and [g]), it serves as the base for the words in (29) as well. If the non-alternating <*kitʃ, kitʃi*> type of paradigm becomes lexically more dominant in the language than the alternating <*mat, matʃi*> type of paradigm, the rule [tʃi]→ [t] would have extremely low confidence. Therefore, Albright suggests that the alternating forms are memorized as irregular exceptions, an idea which coincides with the multi-input approach presented in the previous sections.

The fact that opaque alternations tend to be eliminated (cf. Wetzels 1981, Kiparsky 1982), is also satisfactorily predicted by the current model. Albright (2005*b*:17) assumes that "errors (by children or adults) are overwhelming overregularizations (that is, replacement of irregular forms by grammatically expected forms)." On analogy with regular paradigms, the learner would expect the singular of *matʃi* to be *matʃ*. So, the model predicts that the <*mat, matʃi*> paradigm may change to <*matʃ, matʃi*>. Since the plural is adopted as the base form, converse changes are not predicted, i.e. the plural of *mat* becoming **mati*, or the plural of *pot* becoming **potʃi* (on analogy with <*mat, matʃi*>). Thus, this model of paradigm acquisition predicts which forms will be affected and in which direction the change goes. It provides us with an explanatory generalization concerning analogical change, namely that analogical change is more than a phonological effect of paradigm uniformity; actually it can be interpreted as a morphological effect that results from the way that paradigms are learned. In the next section, we will see how the model makes the correct predictions for the monophthong–diphthong alternations in Italian and how this insight can be accommodated within an optimality-theoretic analysis.

3.2 Analogical levelling of the monopthong–diphthong alternation

In order to discover the generalizations behind the elimination of alternations caused by the 'mobile diphthong rule', we will construct a (simplified) subgrammar of vowel quality alternation in Italian verb paradigms. The implications of this subgrammar will – mutatis mutandis – also hold for other types of paradigms, including derivational ones.

Most verb paradigms in Italian do not show vowel quality alternations:

(30) Paradigms without alternations

PRES IND/3SG	INFINITIVE	Gloss
gr[iː]da	gr[i]dàre	‘to shout’
v[iː]ra	v[i]ràre	‘to bend’
c[uː]ra	c[u]ràre	‘to cure’
r[uː]ba	r[u]bàre	‘to steal’
[aː]ma	[a]màre	‘to love’
r[aː]sa	r[a]sàre	‘to shave’

However, in a large number of paradigms, surface contrasts are neutralized. Consider the following sets of forms, some of which do not show vowel alternations (31a), while others do (31b):

(31) Phonological neutralization

a. Non-alternating stems

PRES IND/3SG	INFINITIVE	Gloss
v[eː]de	v[e]dére	‘to see’
m[eː]na	m[e]nàre	‘to lead’
d[oː]na	d[o]nàre	‘to donate’
v[oː]la	v[o]làre	‘to fly’

b. Alternating stems

PRES IND/3SG	INFINITIVE	Gloss
ann[ɔː]ta	ann[o]tàre	‘to note’
d[ɔ]rme	d[o]rmìre	‘to sleep’
c[ɔː]pre	c[o]prìre	‘to cover’
p[ɛ]nsa	p[e]nsàre	‘to think’
pr[ɛː]da	pr[e]dàre	‘to plunder’
r[ɛː]ca	r[e]càre	‘to bring’

According to the paradigm acquisition model discussed in the previous section, the learner can discover that Italian has a vowel raising process which neutralizes the contrast between mid-low and mid-high vowels in unstressed syllables. The acquisition proceeds in two steps: (a) base discovery and (b) rule construction:

- Base discovery: by comparing the third person singular (p[ɛ]nsa) with the infinitive (*p*[e]*nsàre*) and by comparing *p*[ɛ]*nsa* ~ *p*[e]*nsàre* with *v*[eː]*de* ~ *v*[e]*dére*, the learner discovers that the language has a process of vowel raising and not lowering, since otherwise he would find 3SG **v*[ɛː]*de*; quality contrasts are preserved in the singular forms and therefore these forms constitute reliable bases to construct the remaining paradigm members.

- Rule construction: the learner sets up two rules: ['ɛ 'ɔ] → [e, o] and ['e, 'o] → [e, o], each having 100 percent accuracy; from a hypothetical new form *pr*[ɔ:]*pa* PRES IND/3SG, he would, with 100 percent certainty, derive the correct infinitive: *propare*.

This process of vowel raising is robust in modern Italian, whereas another process – stressed open syllable diphthongization – seems to have lost its robustness due to the emergence of other processes (see 26). Thus, the learner may be confronted with the following forms:

(32) Opacity

PRES IND/3SG	INFINITIVE	Gloss
s[wɔ]na	s[o]nàre	'to ring'
n[wɔ]ta	n[wo]tàre	'to swim'
pr[ɔ:]va	pr[o]vàre	'to try'

In a system in which the majority of the verbs have non-alternating nuclei and in which alternations due to vowel raising are robust, the <*s*[wɔ]*na*, *s*[o]*nàre*> type of paradigm is confusing and the only way to produce such alternating forms is, as argued above in our discussion of <*mat, matʃi*>, to memorize them as irregular inflectional (or derivational) forms. Albright's theory predicts that this double input may be regularized by error, on analogy with other paradigms. It also predicts the direction of the change. Since the third person singular of the indicative is more informative about contrasts in the nucleus of the verb stem than the infinitive, we expect the diphthong to be extended from the present indicative singular to the infinitive, i.e. <*s*[wɔ]*na*, *s*[wo]*nàre*>, on analogy with regular paradigms. And, as we know, this is the correct prediction.[6]

In a sense, then, Albright's theory of analogical change is determined by input regularization. In Optimality Theory this mechanism is referred to as Lexicon Optimization and it is precisely this strategy that we will focus on now. In (33) we repeat the forms listed in (32), this time with their respective input forms.

(33)

PRES IND/3SG	INFINITIVE	Input
s[wɔ]na	s[o]nàre	/sɔn/, /swɔn/
n[wɔ]ta	n[wo]tàre	/nwɔt/
pr[ɔ:]va	pr[o]vàre	/prɔv/

It is unlikely that learners who – initially by error – eliminate the monophthong–diphthong alternation, still posit double input allomorphs. It is more plausible that the input forms of the levelled paradigms are reanalysed: if the output forms of a verb as *s(u)onare* are erroneously produced as <*s*[wɔ]*na*, *s*[wo]*nàre*>, the learner will choose /swɔn/ as the underlying form, because that form will do. In fact, the newly posited input is not merely stipulated, but it has the phonological shape of the form that, within the language under analysis, functions as a base within the paradigm, e.g. the 3rd person singular of the present indicative in Italian verb paradigms. This strategy of selecting optimal inputs is called Lexicon Optimization in Prince and Smolensky (1993/2004: 209).

In order to evaluate surface resemblances among morphologically related words, OT analysts have proposed to invoke either output-to-output correspondence constraints (Benua 1997) or uniformity constraints that evaluate the entire inflectional paradigm (Kenstowicz 1996) or a mix of both (McCarthy's 2005 Optimal Paradigm model). In these approaches, surface resemblance is schematized as the promotion of a constraint demanding this. With this background, we shall again take a look at the facts of Italian. The following tableau illustrates the early stage of the grammar, featuring the monophthong-diphthong alternation:

(34) Early grammar: alternation

/sɔn/ /swɔn/ } + a, are	DEP/MAX$_{seg}$	* $N_{\mu\mu}$	m ↔ μ
a. 'sɔ:.na, sɔ'na:.re		*!	
b. 'sw$_{\mu}$ɔ$_{\mu}$.na, swo$_{\mu}$.'na:.re		*!	*
c. ☞'sw$_{\mu}$ɔ$_{\mu}$.na, so'na:.re			*
d. 'sɔ:.na, swo$_{\mu}$.'na:.re			**!

The next stage is one in which paradigm uniformity comes in, when the effects of the mobile diphthong rule became less perceptible for language learners because of other changes in the languages (see 26). Unlike Kenstowicz and McCarthy, we propose that the paradigm uniformity constraints do not interact directly with constraints such as MAX$_{seg}$ or $N_{\mu\mu}$. Following Van de Weijer (1999) we claim that constraints which inspect entire paradigms cannot be ranked alongside constraints which evaluate individual forms. Besides, paradigm uniformity constraints fail to explain analogy, since analogy is a diachronic phenomenon, occurring in the course of language acquisition, and as such it requires a diachronic solution (cf. Reiss 1997). A more appropriate account is Van de Weijers's idea of Paradigm Uniformity as a kind of (violable) meta-constraint that overlooks the whole grammar, in the spirit of the tableaux des tableaux technique suggested by Prince and Smolensky (1993/2004) to formalize Lexicon Optimization.

In the following (meta-)tableau the non-levelled paradigm of the early grammar is compared to the levelled paradigm that occurs most frequently in the modern grammar:

(35) The meta-constraint PARADIGM UNIFORMITY

	PARADIGM UNIFORMITY
a. /sɔn/, /swɔn/ 'sɔ:.na, sɔ'na:.re	*!*
b. /sɔn/, /swɔn/ 'sw$_{\mu}$ɔ$_{\mu}$.na, swo$_{\mu}$.'na:.re	*!*
c. /sɔn/, /swɔn/ 'sw$_{\mu}$ɔ$_{\mu}$.na, swo'na:.re	*
d. /sɔn/, /swɔn/ 'sɔ:.na, so$_{\mu}$.'na:.re	*

Note that all candidate paradigms incur violations of PARADIGM UNIFORMITY, because of the alternation between open and closed vowels (see 31b). After a stage of variation, candidate (35c) won, for reasons that we explained in the first part of the section and which gave us the insight that analogical change, instead of being a merely phonological effect, is rather a morphological effect that results from the way that paradigms are learned.

If, in a subsequent language stage, language learners are constantly exposed to a candidate of the type (35c), there is no need to assume double inputs, hence the input form is restructured and Lexicon Optimization takes place, as shown in tableau (36).

(36) Modern grammar: no alternation and single input

/swɔn/ +a, are	DEP/ MAX$_{seg}$	*N$_{\mu\mu}$	m ↔ μ
a. 'sɔ:.na, so'na:.re	*!*	*	
b. ☞'sw$_{\mu}$ɔ$_{\mu}$.na, swo$_{\mu}$.'na:.re		*	*
c. 'sw$_{\mu}$ɔ$_{\mu}$.na, so'na:.re	*!		*
d. 'sɔ:.na, swo$_{\mu}$.'na:.re	*!		**

From written and spoken sources we know that both [e,o] and [je,wo] variants persisted for a very long time. In fact, variation, albeit little – is still found at present. It is also known that grammars and dictionaries included the *regola del dittongo mobile*, from the 16th century onwards up until today. In the 20th century the rule was still defended by a number of linguistic purists (Gabrielli 1956, 1980; Cappucini and Migliorini 1962, Migliorini, Tagliavi and Fiorelli 1969). This fact may certainly have slowed down the leveling process, especially in a community which only in the last century was unified linguistically.[7]

To conclude this section, we claim that analogical change shows that allomorphy must be listed lexically. As Wetzels (1981) puts is, analogical change is the effect of the competition between stored form and rule-based form; the rule-based form wins if the activation level of the stored form is low enough to be overruled by the rule-based form.

4 Storage versus computation

So far, we have argued that the allomorphs have to be listed lexically. This raises the question whether we should assume that the allomorphs are stored as such, or rather as parts of inflected or derived words? We think that the second answer is the correct one: allomorphs are memorized as parts of the words in which they appear, as was presupposed by the analysis of analogical change in section 3.

This assumption is in line with the general psycholinguistic and historical evidence that many inflected and derived words are stored in the lexicon. This is obviously the case for words with some unpredictable property, but this even applies to inflected and derived words that are completely regular, provided that they have a certain frequency of use. These frequency effects are found in lexical decision tasks (cf. Booij 1999 and the references cited there), and frequency effects presuppose lexical storage.

Historical phonological evidence for this assumption is that the outputs of a phonological rule may survive even though the relevant phonological rule got lost. Middle Dutch, for instance, had a rule of vowel lengthening in stressed open syllables. This rule is no longer active. Yet, we still find a number of plural forms with long vowels, whereas the singular form has a short vowel. That is, modern Dutch features pairs of nouns such as *pad* [pɑt] – *pad-en* [paːdən] 'path-paths'. Hence, the plural form *paden* must have been stored in order to survive after the loss of the rule of vowel lengthening (Booij 2002).

This assumption also explains why in particular derived words are often immune to analogical change, since derived words tend to be stored at a more extensive scale than inflected forms of words. For example, the word *pedone* 'pedestrian' will be listed besides the word *piede* 'foot'. Therefore, its phonetic form does not have to computed, and the allomorph *pied-* will therefore not get the chance to be combined with *-one*.

In languages with rich inflectional paradigms such as Italian at least a subset of the inflectional forms will still be computed rather than stored, and hence analogical change can take place. Crucially, analogical change will only take place if computation is involved.

There are two ways of computing a new form. The first option is along the lines of the analysis of section 2. This applies in case the language user has both allomorphs as his disposition. If a word has to be used that is not available through direct lexical retrieval (or has a very low degree of activation which makes retrieval slow), the word will be computed. Both root allomorphs as listed in paradigmatically related words or word forms will occur in the candidate set. In this way the alternation will be maintained. The second option is that the language user takes only one root allomorph into account for the computation of the correct word (form), the allomorph that is lexically dominant (cf. section 3). This will lead to analogical change, with only one allomorph of the root being used in new word(form)s.

In conclusion, proper assumptions about the balance between storage and computation, in combination with a model of phonological computation in which allomorphs are listed and a set of ranked output conditions serves to select the optimal allomorph enabled us to give an insightful account of the Italian mobile diphthongs, both from a synchronic and a diachronic perspective.

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[1] Cf. Vogel (1993: 226), who also claims that "a (morpho)phonological rule can be used to diphthongize the appropriate vowels", deriving the correct outputs from one single stem, although she admits that "it is not predictable which verbs with *-e-* and *-o-* in their roots exhibit diphthongization."

[2] In OT literature the relationship between stress and bimoraicity is commonly captured by two different constraints: STRESS-TO-WEIGHT and WEIGHT-TO-STRESS. In some analyses, however, the distinction between these constraints becomes unclear. Following Van der Veer (2006), we argue that confusions of this type may raise the question whether these two separate constraints might not be better understood as the consequences of one single constraint which covers both directions in the stress/weught relationship.

[3] In these tableaux constraint violations are only indicated if the relevant (i.e. first) syllable of each output candidate does not meet the requirements posited by a particular constraint.

[4] As things stand in tableau (15), the not shown ['sj$_{\mu}$ɛ$_{\mu}$.de.te] candidate would win over the grammatical candidate [se.'de$_{\mu\mu}$.te]. However, high-ranked metrical constraints responsible for Italian stress (see D'Imperio and Rosenthall 1999) prevents stress from landing on the antepenultimate syllable here.

[5] For a more detailed description of palatalization (or velar softening), the reader is referred to Halle (2005).

[6] There is a very small number of exceptions. Alternations persist in the paradigms of highly irregular verbs such as *dolere* 'to hurt', *morire* 'to die', *tenere* 'to hold' and *venire* 'to come' and in a number of (etymological) derivations which are stored as indivisible items in the lexicon, such as *coraggio* 'courage' (cf. *cuore* 'heart') and *pedone* 'pedestrian' (cf. *piede* 'foot'). In three verb paradigms (*negare*, 'to deny', *levare* 'to raise' and *coprire* 'to cover') levelling has occurred in the opposite direction, i.e. the monophthong is found throughout the paradigm. The diphthongized forms of these verbs, e.g. *n*[jE]*go* and *c*[wO]*pro*, are archaic (cf. Sabatini and Coletti 1997) and we must assume that their paradigms were already levelled by the time the monophthong–diphthong alternation was levelled through extension of the diphthongs.

[7] To get an idea of the linguistic diversity in Italy halfway the twentieth century, we quote some numbers from De Mauro (1976): in 1951, 18.5% of the Italians used only the

standard language, 13% only a dialect, 87% were capable of using standard Italian and 63.5% used a dialect in most situations.

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