Rules, constraints, and lexical phonology in Glenoe Scots

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0 Introduction*

Glenoe Scots, a variety of Ulster Scots spoken in the village of Glenoe about twenty miles north of Belfast (Gregg 1958, 1959, 1973, 1985), displays a peculiar interaction between phonology and inflection: a lexical pattern systematically fails to occur not only in irregular plurals but also in the present tense forms of a specific class of irregular verbs. I show that this interaction cannot be handled by rules, but instead requires an analysis with an associative and dynamic lexicon of the sort recently argued by Pinker and Prince (1992) to be necessary for the description of irregular inflection. I suggest how this notion may be expressed with the device of schemas (Bybee and Slobin 1982), which are relatively loose, nonderivational generalizations across forms that share a family resemblance in a particular lexicon. I further show that the constraints of Optimality Theory (Prince and Smolensky ms.), which are similar to schemas in being nonderivational and violable, face many of the same problems as rules in describing Glenoe Scots. However, if rather substantial portions of the associative analysis are carried over, in particular the reference to a specific lexicon, Optimality Theory does allow a more precise formalization of the insights into the lexicon made by Pinker and Prince (1992) and Bybee and Slobin (1982). I end the paper by considering the plausibility of developing a theory of lexical phonology founded on an associative lexicon.

1 The rule

Glenoe Scots is subject to a process that may be termed *Scottish Lowering*, whereby the diphthong [×y] is lowered to [ay] in open syllables and before voiced continuants, except after /w/. I formalize Lowering as in (1), with examples in (2) illustrating the pattern.

(1) Scottish Lowering[1]

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$\varnothing \rightarrow$ [+low] / ([-round]) _ [-back] ([+continuant, +voice]) $]_{\sigma}$

(2) Motivation for Lowering[2]

a. Relevance of open syllables:

tay	'tie'	[cf.	t×yd	'tide']
fay^{a}l	'phial'	[cf.	f×yl	'file']

b. Relevance of [+voice]:

fayv	'five'	[cf.	f×yf	'fife']
prayz	'prize'	[cf.	pr×ys	'price']

c. Relevance of [+continuant]:

say¶	'scythe'	[cf.	b^{a}s×yd	'beside']

d. Relevance of [-round]:

bay	'buy'	[cf.	hw×y	'why']
prayz	'prize'	[cf.	w×yz	'wise']

Lowering possesses at least two of the diagnostics for a lexical rule (see, e.g., Kaisse and Hargus 1993). First, in certain words [×y] unexpectedly appears in environments where Lowering should apply. Two examples of these lexically marked exceptions are given below.

(3)

g×y	'very'	[cf.	gay	'guy']
º×y	'shy'	[cf.	stay	'(pig) sty']

Second, Lowering is sensitive to morphological structure. As illustrated below, Lowering is not blocked by material added through regular inflection or certain other processes. If Lowering were postlexical, it should fail to apply in tied just as it does in tide.

(4)

a.	tay	'tie'	tayd	'tied'
			[cf. t×yd	'tide']
b.	may	'my'	mayn	'mine (pron.)'
			[cf. m×yn	'mine (n.)']

2 The interaction

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[1]While hardly elegant, the rule in (1) uses no formal device not already required by familiar lexical rules in English (see, for example, the rule formalizations in Halle and Mohanan 1985).

[2]In all of Gregg's work, [×y] is transcribed as [^{a}i]. Gregg (1958, 1959, 1985) transcribes [ay] as [Œe] or [Œːe] to reflect the fact that it is lengthened; Gregg (1973) ignores length and transcribes it as [aÜ]. These slight differences in transcription do not affect the point I am making here.

What is peculiar is that Lowering systematically fails to apply in specific classes of irregular forms. Consider first the examples below, where Lowering fails to apply in irregularly inflected plural forms. The idiosyncratic voicing of the postvocalic consonants does not trigger Lowering as one might expect.

(5) l×yf 'life' l×yvz 'lives' [cf. layv 'live (adj.)']
n×yf 'knife' n×yvz 'knives'

As Gregg (1973) recognizes, these exceptions are easy to handle by means of rule ordering, specifically, the ordering of Lowering before some idiosyncratic rule of Irregular Voicing. As illustrated by the derivations below, at the point where Lowering would apply, the postvocalic consonants in the irregular plurals would not yet be voiced.

(6)

	'lives'	'hives'
	/l×yf + z/	/h×yv + z/
Lowering	---	hayvz
Irregular Voicing	l×yvz	---

However, no rule ordering analysis is possible for what is found in irregular past tense inflection, casting doubt on the use of such an analysis for irregular plurals as well. In verbs, Lowering again fails to apply in an irregular class, but this time the exceptions are the uninflected forms. This means that the only way to predict that Lowering applies in the present tense form <u>dive</u> (which is regular in Glenoe Scots) but not in the present tense form <u>drive</u> (which is irregular) is on the basis of the associated past tense forms.

(7) a. dr×yv 'drive' drowv 'drove'
r×yz 'rise' rowz 'rose'
r×yv 'thrive' rowv 'throve'
str×yv 'strive' strowv 'strove'

b. dayv 'dive' dayvd 'dived'
prayz 'prise' prayzd 'prised'
ᵃrayv 'arrive' ᵃrayvd 'arrived'
rᵃvayz 'revise' rᵃvayzd 'revised'

It is not that Lowering fails to apply in irregular forms in general, since even among irregular verbs Lowering only fails to apply in verbs of the [ay]-[ow] class.

For example, the irregular verb buy, whose past tense form bought does not contain [ow], undergoes Lowering as it should and surfaces as [bay].

Nor can one dismiss Lowering as a mere historical relic. The synchronic relevance of the rule and its interaction with irregular inflection is demonstrated by the following observation of Gregg (1973, 1985). With Glenoe speakers for whom strive has become a regular verb (with past tense strived), this form no longer violates Lowering and is pronounced [strayv].

The simplest way for a rule-based analysis to handle these facts would be to stipulate that all irregular verbs of the [ay]-[ow] class are marked as exceptions to Lowering, perhaps by representing their underlying diphthongs differently. However, this approach is unsatisfying since it does little more than restate the problem.

More seriously, there is good reason to believe that any rule-based approach to the interaction between Lowering and irregular inflection is simply inappropriate since, as I show in the next section, irregular inflection does not appear to involve rules.

3 The associative nature of irregular inflection

Pinker and Prince (1992; see also Pinker 1991 and references therein) summarize the results of a wide range of linguistic, psycholinguistic and neurolinguistic studies which suggest that irregular inflection must be sharply distinguished from regular inflection. While regularly inflected forms are derived by rule from stem forms in the lexicon, as is standardly held, irregularly inflected forms do not appear to be derived at all. Instead, they are listed in the lexicon along with their uninflected stem forms; patterns involving irregular inflection emerge through associative effects. That is, according to Pinker and Prince (1992: 233),

> generative theories are fundamentally correct in their characterization of productive rules and structures, but deficient in the way they characterize memory of less predictable material, which must be associative and dynamic, somewhat as connectionism portrays it.... If our approach is correct, the reason they [e.g., patterns involving irregular inflection] don't act like bona fide rules is that they are not rules at all, but epiphenomena of the way structured lexical entries are partially superimposed in memory.

Putting the claim into more familiar linguistic terminology, patterns in irregular inflection arise not by rule, but by what Bybee and Slobin (1982) call

schemas: relatively loose, nonderivational generalizations across form classes in a particular lexicon.

The systematic nature of schemas can be illustrated by the following two properties of irregular inflection. First, patterns of irregular inflection are semiproductive. For example, dive was once a regular verb, as it still is in Glenoe Scots, but in many dialects its past tense form is now dove, conforming to the pattern seen in such pairs as drive-drove and ride-rode. Second, forms that take part in a given irregular pattern are phonologically similar, which would not be expected if irregular forms were simply arbitrary exceptions. Thus most of the irregular verbs that show the [ay]-[ow] alternation are similar to dive-dove in ending in a voiced and/or continuant obstruent.

Nevertheless, such signs of systematicity cannot be attributed to rules. This is because schemas are not categorical: any given phonological property of an irregular form is neither necessary nor sufficient to predict which pattern it will conform to. Rather, schemas are defined by family resemblances among individual forms, so that for any form in an irregular class there is another that shares most of its features. This can be seen in the set of irregular verbs of the [ay]-[ow] class listed in Bloch (1947) (I have left out dive, which is regular in Glenoe Scots).

(8)

bide-bode	drive-drove	ride-rode	rise-rose
shrive-shrove	smite-smote	stride-strode	
strive-strove	thrive-throve	write-wrote	

The rimes of drive, shrive, strive and thrive are identical; the rime of rise differs from these only in the place of the final consonant; the rimes of bide, ride and stride differ from that of rise only in the value of [continuant]; the rimes of smite and write differ from that of ride only in the value of [voice]. The close similarities between forms when compared in a pairwise fashion gives the class a phonological cohesiveness that is not expressible by means of a specific property that singles out the class as a whole.

The patterns of irregular inflection must therefore be described with associations between individual pairs of items and not by general rules, since family resemblances can only be seen through pairwise comparisons of forms. Although this implies that a complete formal characterization of a speakers' knowledge of irregular inflection would require not only general principles of representation and association but also the listing of all relevant items in a specific lexicon, a general picture of how irregular patterns arise without rules is easy to understand. The past tense of dive, for example, changed because the phonological representation of dive overlaps with that of drive and drive is associated to drove;

this set of associations was strengthened when the past tense of dive became dove, which overlaps with drove. In the terms of Bybee and Slobin (1982), the past tense of dive changed to conform to the schema 'A past tense form may contain [ow].' This schema, which holds by virtue of the fact that many past tense forms (such as drove) do in fact contain [ow], was relevant in the case of dive because drive and dive share a family resemblance.

Schemas are similar to the constraints of Optimality Theory (Prince and Smolensky ms.) in that they are nonderivational and violable. They differ, however, in that schemas need not be universal, since they are generalizations made over specific lexicons. Moreover, the pairwise comparisons required to see family resemblances are as problematic for Optimality Theory as they are for rule-based theories. This will be made clear in a later section.

In spite of the complexity of modeling an entire lexicon, the associative approach to irregular inflection appears to be superior to a rule-based approach. Any analysis of irregular inflection using rules (for example Halle and Mohanan 1985, Halle and Marantz 1993) must resort to arbitrary diacritics to indicate which irregular forms undergo which rules. Such diacritics neglect not only the family resemblances that provide phonological coherence to irregular classes but also the pairwise comparisons that family resemblances entail. Rule-based approaches also fail to deal with the numerous other arguments compiled by Pinker and Prince (1992) which strongly suggest that irregular inflection is not governed by rules.

4 The associative nature of the interaction

It is not difficult to accept the view of irregular inflection espoused by Pinker and Prince (1992) as essentially correct, since even the term 'irregular inflection' reflects its longtime reputation of being less than rule-like. Once we accept their view, however, we are forced to conclude that rules are equally inappropriate for expressing the interaction between irregular inflection and Lowering in Glenoe Scots. We cannot explain why Lowering fails to apply in irregular plurals by ordering it before some rule of Irregular Voicing, since the idiosyncratic forms of irregular plurals are not derived through phonological rules but rather arise by conforming to associative schemas. Nor can we use any analysis that requires reference to an irregularity diacritic. A general diacritic of the form [+irregular] would incorrectly predict that buy is an exception to Lowering; a diacritic to single out just the [ay]-[ow] class would miss the family resemblances that hold this class together.

By contrast, the outlines of an associative analysis of the Glenoe Scots phenomena are quite straightforward. The reason that a form like drive does not undergo Lowering is that its past tense form drove is phonologically similar to a form like rode, whose present tense form ride does not meet the phonological

conditions for Lowering (Lowering does not apply before stops). Thus it is not the mere fact of a form's morphological irregularity that makes it an exception to Lowering, but rather the phonological and morphological properties of the form's lexical neighbors.

Stated generally, the associative analysis claims that Lowering fails to apply in all and only those forms which meet the following conditions: (a) the form F is in the lexicon; (b) F is inflectionally associated with another form F' which is also in the lexicon; (c) F and F' share a family resemblance with forms G and G', respectively, which are also in the lexicon and inflectionally associated; (d) G and G' are part of a consistent inflectional pattern; (e) the forms in this pattern do not meet the structural description of Lowering. Given the findings reported in Pinker and Prince (1992), the stipulation that the forms be in the lexicon means that they are either uninflected or irregularly inflected. Lowering is thus correctly predicted to apply in regularly inflected forms.

Among the irregular verbs, these conditions do in fact hold of all and only the forms where Lowering fails to apply. The only forms sharing a family resemblance with drive, rise, thrive and strive and which are irregularly inflected according to the same schema are the verbs listed above in (8), where the conditions for Lowering are not met. By contrast, Lowering applies in irregular verbs that conform to other schemas because the present tense forms of such verbs do not share enough of a family resemblance to have a consistent associative effect. This can be seen in the following list of all verbs which, like buy, conform to the schema 'A past tense form may end in [¿t].' The present tense forms display a bewildering array of rimes, effectively swamping any influence that fight, the lone form containing [×y], may have on buy.

(9) beseech-besought bring-brought buy-bought
catch-caught fight-fought seek-sought
teach-taught think-thought work-wrought

In order for this analysis to hold of the irregular plurals as well, we require the existence of a consistent class of forms that share a family resemblance with lives and knives and are pluralized in the same irregular way, but in which the phonological conditions for Lowering are not met. No such prediction is made by the rule ordering analysis presented earlier, since for analyses without an associative lexicon the specific content of the lexicon is relevant only if it gives evidence for general rules or constraints. Thus it is all the more surprising that a consistent class of forms meeting the conditions does in fact exist, namely the set containing the word wives [w×yvz]; as noted above, Lowering does not apply after

/w/. No other noun with the irregular pluralization seen in lives contains either [ay] or [×y].

It is reasonable to ask why the diphthong in wives influences those in lives and knives rather than the other way around, which would generate [wayvz] as a 'positive exception' to Lowering. Unfortunately, the associative model of the lexicon I adopt from Pinker and Prince (1992) and Bybee and Slobin (1982) is too imprecise to provide an answer (although I suggest a possible explanation in the following sections). The fact remains, however, that the associative analysis, unlike rule-based analyses, correctly predicts the existence of forms like ride and wives in the first place, as well as the application of Lowering in irregular verbs like buy.

In essence, the analysis of the interaction of Lowering with irregular inflection in Glenoe Scots is identical to the analysis by Pinker and Prince (1992) of irregular inflection in general. Thus the schemas reflected in the pair ride-rode are extended to the pair rise-rose, even down to the specific value of the diphthong; it is [×y] in ride, so it is [×y] in rise as well.

5 The associative nature of Lowering

Where does this analysis leave our understanding of Lowering itself? One possibility is to continue to describe Lowering as a rule. If it is a rule, we must stipulate that it is ordered before the associative effects that give rise to the patterns of irregular inflection. We already saw that this was the case with Lowering and the idiosyncratic voicing that occurs in the irregular plurals. It is equally true of the behavior of Lowering in the irregular verbs. This can be illustrated through the hypothetical derivations shown below, where 'Irregular schemas' represents the associative patterns of irregular inflection.

(10)

	'drive' /dr×yv/	'dive' /d×yv/
Lowering	drayv	dayv
Irregular schemas	dr×yv	---

Analyzing Lowering as a rule is unsatisfying for two reasons, however. First, a fundamental proposal of Pinker and Prince (1992) is that the behavior of irregular inflection follows automatically from the fact that irregularly inflected forms are listed in the lexicon, and are thereby subject to associative effects, while regularly inflected forms, which are not listed in the lexicon, are not subject to such effects. In order for rules to apply before these effects, they would have to apply 'before the lexicon' in a sense that is rather difficult to conceptualize.

Second, with Lowering considered a rule, we are forced to stipulate its ordering relative to the irregular schemas. This may not be the case if we think of Lowering as an associative schema. To make this clear, first consider the schemas for the relevant irregular plurals and verbs.

(11) a. A plural form may end in a [+voice] segment
b. A past tense form may contain [ow]

Suppose now that the schema for Lowering takes the form given in the figure below.

(12) [+low] may appear in the context
([-round]) _ [-back] ([+continuant, +voice]) $]_{\sigma}$

Notice that while the schemas for irregular inflection contain references to morphological relations, the schema for Lowering does not. A schema like 'A past tense form may contain [ow]' entails associations not only among forms containing [ow] but also between past tense forms and the associated present tense forms. By contrast, the schema for Lowering only entails associations among forms with the given phonological properties. We would therefore not expect Lowering to have as much 'associative strength' as the irregular schemas. For this intuition to carry theoretical weight, of course, the concept of 'associative strength' must be made more precise than is possible in this paper.

6 An Optimality analysis

Some of the problems for a rule-based analysis of Lowering seem to be due to the fact that rules take part in a derivation, while the view of the lexicon in Pinker and Prince (1992) as 'associative and dynamic' implies that derivations have no place in the lexicon. *Optimality Theory* (Prince and Smolensky ms.), which proposes that phonology be analyzed entirely with nonderivational constraints, therefore seems like a viable alternative. This is especially so because Optimality Theory (OT) has historical antecedents in Harmony Theory (e.g. Smolensky 1986), which, while not itself a connectionist model, is a way of abstracting out the crucial properties of a class of connectionist networks that maximize harmony.

I show, however, that OT possesses properties, some of which it shares with rule-based analyses, that indicate that it too is inadequate as a model of lexical phonology in Glenoe Scots. First, it cannot express the family resemblances that give the classes of exceptions to Lowering their phonological coherence. More generally, it denies the evidence given above that phonological patterns can be sensitive to the specific contents of the lexicon. Finally, it appears that the only

way we can get an OT analysis of Glenoe Scots to work is if we import into it several crucial characteristics of the associative view of the lexicon which OT had attempted to abstract away from.

All of these problems follow automatically from the device of constraints in OT, which, like rules in rule-based analyses, are theoretically independent of specific lexicons. I will demonstrate this by attempting to create an OT analysis of the phenomena in Glenoe Scots.

First, some basics, abstracted from Prince and Smolensky (ms.). Though violable, OT constraints are proposed to be drawn from a universal set. A grammar consists of rankings of these constraints, with violations of a higher ranked constraint counting more than violations of a lower ranked constraint. Candidate forms, essentially all variations on a single 'input' form describable within a fixed representational system, are evaluated by these ranked constraints in the following manner: All candidates that violate the highest ranked constraint 'the most' are eliminated, then all candidates that violate the next highest ranked constraint 'the most', and so on, until (ideally) only one candidate remains. This 'optimal' candidate is chosen as the 'output.'

As an introductory example, consider what would happen if we tried to translate into OT the rule-ordering analysis given above of the Lowering-plural interaction. As the constraint version of Lowering, I simply adapt the schema used in the last section as given below.

(13) Lowering

[+low] must appear in the context
([-round]) _ [-back] ([+continuant, +voice]) $]_{\sigma}$

The fact that this monstrosity is hardly universal is not necessarily an argument against OT. It is at least possible that the various parts of the Lowering constraint could be taken out and treated as separate and independent constraints, each of wider use by languages. For example, there are similar alternations between [ay] and [×y] in several North American dialects of English that are also sensitive to syllable structure and voicing, though not to the value of [round] or [continuant] (Chambers 1973, Paradis 1980, Vance 1987).

With similar caveats, the constraint version of Irregular Voicing might be given as follows.

(14) Irregular Voicing

A [+irregular] stem must end in a [+voice] segment

I assume that these constraints are accompanied by the following *Faithfulness Constraints* which make it costly to add structure. The reason the universal constraints of Lowering and Irregular Voicing apply in Glenoe Scots and not in all languages is that in the grammar of Glenoe Scots, Lowering and Irregular Voicing are ranked higher than *Structure ([+low]) and *Structure ([+voice]), respectively. Because in this analysis I am assuming a diacritic feature [irregular], I include a Faithfulness Constraint for this feature as well, which should be ranked rather high to capture the notion that irregularity is marked.

(15) a. *Structure ([+low])

*[+low]

b. *Structure ([+voice])

*[+voice]

c. *Structure ([+irregular])

*[+irregular]

Note that the Faithfulness Constraints block the addition of structure to the input; candidates generated from inputs that already have [+low], [+voice] and [+irregular] do not violate these constraints.

The intuition we want to capture is that Lowering fails to apply in plurals that undergo Irregular Voicing because Lowering is 'weaker' than Irregular Voicing. At first sight it appears that this can be done by ranking Irregular Voicing higher than Lowering. The complete ranking of all five constraints will then be as follows (the relative ranking of *[+low] and *[+voice] is arbitrary).

(16) IrregVoice È Lowering È *[+irreg] È *[+low] È *[+voice]

To make the analysis concrete, let us choose three sample inputs, namely, one irregular plural, one regular plural whose stem ends in /v/, and one regular plural whose stem ends in /f/. These input forms are given below, with the assumptions that /v/ is marked [+voice] but /f/ is unspecified for voicing, and that /a/ is marked [+low] but /×/ is unspecified for low.

(16) a. 'knife' n×yf [+irreg]

b. 'hive' h×yv
|
[+vce]

c. 'fife' f×yf

The relevant candidate outputs generated from these inputs are as given below. The fact that all the candidates for knife are marked [+irreg] and all those for hive end in a [+voice] segment follows from the assumption that the device that generates candidates (called *Gen*) does not remove structure.

(17) a. 'knife + z'
n×yf + z [+irreg]
n×yv + z [+irreg]
nayf + z [+irreg]
nayv + z [+irreg]

b. 'hive + z'
h×yv + z
hayv + z
h×yv + z [+irreg]
hayv + z [+irreg]

c. 'fife + z'
f×yf + z
f×yv + z
fayf + z
fayv + z
f×yf + z [+irreg]
f×yv + z [+irreg]
fayf + z [+irreg]
fayv + z [+irreg]

The effect of the constraints on these candidates can be made clear with what are called *constraint tableaux.* The constraint tableaux associated with our three sample inputs are given below. The optimal candidate in each case is marked with an arrow.

(18) Constraint tableau for knives

Candidates	IrregVoice	Lowering	*[+irreg]	*[+low]	*[+voice]
n×yf + z [+irreg]	*				
80 n×yv + z [+irreg]		*			*
nayf + z [+irreg]	*			*	
80 ⇒ nayv + z [+irreg]				*	*

(19) Constraint tableau for hives

Candidates	IrregVoice	Lowering	*[+irreg]	*[+low]	*[+voice]
h×yv + z		*			
80 ⇒ hayv + z				*	
h×yv + z [+irreg]		*	*		
80 hayv + z [+irreg]			*	*	

(20) Constraint tableau for fife

Candidates	IrregVoice	Lowering	*[+irreg]	*[+low]	*[+voice]
⇒ f×yf + z					
80 f×yv + z		*			*
fayf + z				*	
80 fayv + z				*	*
f×yf + z [+irreg]	*		*		
f×yv + z [+irreg]		*	*		*
fayf + z [+irreg]	*		*	*	
80 fayv + z [+irreg]			*	*	*

As can be seen, this analysis correctly selects the outputs /f×yf+z/ for fifes and /hayv+z/ for hives. Unfortunately, it also incorrectly selects /nayv+z/ for knives, failing to describe precisely the pattern we designed the analysis to describe.

Of course it is possible that we have simply made bad choices in our constraints, representations, or rankings, but I suggest that any alternative along these lines will continue to face the major problems that ultimately did in the parallel rule ordering analysis. First, given the arguments concerning irregular inflection and family resemblances, the use of the feature [+irregular] is ad hoc at best. Second, according to Pinker and Prince (1992), there should be no rule, much less a universal constraint, of Irregular Voicing. Third, even if we could get ordering to work in nouns, no ordering analysis works for the irregular verbs because there the exceptions to Lowering are in the uninflected forms, meaning there is no irregular constraint like Irregular Voicing available to rank over Lowering. Fourth, the analysis continues to ignore the evidence that the overriding of Lowering in forms like knives and rise depends on the existence of forms like wives and ride elsewhere in the lexicon. All of these problems provide challenges just as serious for OT as they are for rule-based analyses, and for the same reason:

in contrast to the assumption made by these approaches, lexical phonology actually behaves as if it were not at all independent of particular lexical items.

Ironically, however, the failure of the above analysis may be an advantage of OT in disguise. If OT is appropriate for describing an associative lexicon, as its heritage leads one to hope, then it is fitting that the parody of a derivation represented by the above analysis should not work. Instead, we should attempt to translate into OT not rule-based analyses but rather the associative analysis sketched in earlier sections.

Recall that the insight there was that Lowering was inherently weaker than the [×yf]-[×yv] pattern of irregular plurals and the [×y]-[ow] pattern of irregular verbs because these included morphological associations rather than just phonological ones. The suggestion was that this weighting scheme is in fact universal to all associative lexicons. As one simple way to interpret this idea in OT, I propose the following Faithfulness Constraints, to be explicated further below.

(21) a. *Structure (MorphAssoc)

There must be no change in association between forms that are morphologically related to forms that are themselves associated.

b. *Structure (Assoc)

There must be no change in association between forms.

These constraints are ranked as follows. Note that just as in the associative analysis, there is no need to stipulate this ranking in the grammar. In this case, this is because it follows from Panini's Theorem on Constraint-ranking (see Prince and Smolensky, ms.: 81-82), since *MorphAssoc is more specific than *Assoc.

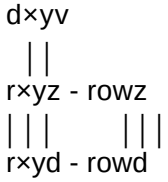
(22) *MorphAssoc È *Assoc

The reader will have already concluded that these new constraints only make sense given a representational system where associations between forms play a role. This is inevitable if we really want to use the insights gained by making generalizations over specific lexicons. Thus my OT analysis will assume that inputs, candidates and outputs are all described within a representational system for *entire associative networks*, not merely for isolated forms.

This is easier to do than it might seem. First, I simply import the representational notation used for individual forms from standard theories.

Specifically, I assume that forms are represented in standard autosegmental notation, where, in the case of the forms to be discussed, /×y/ is distinguished from /ay/ in that the latter has a specification for [+low] on the vowel while the former does not.

Next, for the representation of associations between forms, I simply adapt the notation used in Bybee (1988) and other places, where forms are placed above one another and lines are drawn to link phonological units in the matching prosodically-defined locations in the different forms. For ease of exposition, I will draw the associations between morphologically related forms with horizontal lines, though clearly such forms must be phonologically linked as well in order to explain why they share so much phonological material. As illustration, below I give the subnetwork containing the forms dive, rise, rose, ride and rode; by now the reader should understand why I have not included the form dived. The vertical associations represent links between segments that match in all features.

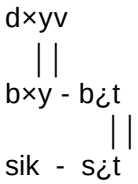
(23)


With this understanding of the representations I will use, the relevant constraint ranking for an analysis of Glenoe Scots is as follows. The constraints Lowering and *[+low] are those defined above, with their relative ranking following from the fact that Lowering is 'turned on' in this particular language. The ranking of Lowering below *MorphAssoc follows from its being a purely phonological constraint; I leave it as an exercise for the reader to determine if this ranking can be made to follow more directly from Panini's Theorem.

(24) *MorphAssoc È Lowering È *[+low] È *Assoc

For the sake of simplicity, I will assume that *MorphAssoc and *Assoc are violated not only whenever one of the lines is added, but also when one is deleted; hence the quasiderivational reference to 'change' in their formulations. Moreover, I must assume that a link will violate these constraints even if there was a link in the same location in the input, if it is the case that the segments linked in the output are different from those in the input. Thus a line linking two /a/'s in the output is not the same as a line linking two /×/'s in the input, and is therefore a violation of *Assoc.

I now illustrate this analysis by examining the input subnetwork given above. I will compare it to the following subnetwork involving the forms dive, buy, bought, seek, and sought, which was chosen to illustrate why associations are not sufficient to force buy to become an exception to Lowering.

(25)


The constraint tableau for the subnetwork containing rise is given below. Note that all candidates violate *MorphAssoc and/or Lowering, apparently leaving two equally optimal forms. Recall, however, that in OT constraints are not only violable, but violable to different degrees. Thus here we must pay attention to the relative degree of the violations of Lowering. Following standard practice, I have given one '*' for each specific instance of a violation of Lowering. Thus if there are two examples of /×y/ appearing before a [+voiced, +continuant] segment in a given subnetwork candidate, I have placed two *'s in the appropriate cell. The same holds for multiple violations of *[+low] and *Assoc. With this understanding, the optimal candidate is the one marked with an arrow, since this is the only one which does not violate *MorphAssoc at all and which violates Lowering only once. Significantly, this optimal candidate is also the correct one, where dive, rise, and ride have the forms /dayv/, /r×yz/, and /r×yd/, respectively.

(26) Constraint tableau for the subnetwork containing <u>rise</u>

Candidates	*MAssoc	Lowering	*[+low]	*Assoc
d×yv || r×yz - rowz ||| ||| r×yd - rowd		**		
d×yv | rayz - rowz | | ||| r×yd - rowd	*	*	*	**
d×yv || r×yz - rowz | | ||| rayd - rowd	*		*	*
d×yv | rayz - rowz ||| ||| rayd - rowd	*	*	**	**
dayv | ⇒ r×yz - rowz ||| ||| r×yd - rowd		*	*	*
dayv || rayz - rowz | | ||| r×yd - rowd	*		**	**

(26) [continued]

Candidates	*MAssoc	Lowering	*[+low]	*Assoc
dayv | r×yz - rowz | | ||| rayd - rowd	*	*	**	**
dayv || rayz - rowz ||| ||| rayd - rowd	*		***	**

Now I give the constraint tableau for a case where the irregular verb should not be made an exception to Lowering. Here the optimal candidate violates neither *MorphAssoc nor Lowering; in fact, none of the candidates violate *MorphAssoc, since buy is not linked to seek. Once again, the OT analysis selects the correct candidate, so that both dive and buy undergo Lowering.

(27) Constraint tableau for the subnetwork containing buy

Candidates	*MAssoc	Lowering	*[+low]	*Assoc
d×yv || b×y - b¿t || sik - s¿t		**		
d×yv | bay - b¿t || sik - s¿t		*	*	*
dayv | b×y - b¿t || sik - s¿t		*	*	*
⇒ dayv || bay - b¿t || sik - s¿t			**	**

Precisely the same constraint ranking will correctly account for the behavior of Lowering in irregular plurals as well. As a moment's thought will reveal, the following subnetwork for the words hive, knife, knives, wife and wives will produce a constraint tableau identical to that in (26) in the placement of *'s, with the optimal candidate being the one where hive, knives, and wives have the forms /hayv/, /n×yvz/, and /w×yvz/, respectively.

(28)

```
          h×yv
            || |
n×yf - n×yvz
  |||      ||||
w×yf - w×yvz
```

The success of this OT analysis teaches us two things. First, it may in fact be useful to interpret violable schemas as violable OT constraints instead, given the substantial increase in formal rigor. Second, however, even an OT analysis will only work if we also assume a rather substantial theory of the associative lexicon. We must make reference to particular items in the lexicon; general constraints alone will not suffice. Moreover, these particular items must be associated in some way to indicate their family resemblance. I have shown one way of doing this;

presumably improvements in descriptive adequacy would result if associative links were made between features and not entire segments. Notice also that the OT analysis I have given simply assumes the preexistence of the [×yf]-[×yv] and [×y]-[ow] patterns in the Glenoe Scots lexicon. A complete analysis should provide some account for how such patterns arise in the first place, and it is unlikely that OT is up to this task.

Since so much of the associative view of the lexicon must be borrowed to make the OT analysis work to the degree that it does, the question is left open whether the unique properties of OT are required at all. If associative representations like those above are allowed, even a rule-based analysis may be able to do the job. In any case, one thing is unambiguous. In spite of its ancestry in certain connectionist models, OT as it now stands is simply too abstract a theory for dealing with the associative effects discussed in this paper.

7 Conclusions: The associative nature of lexical phonology

I consider now the larger implications of Glenoe Scots. To review, the motivations for an associative analysis of Lowering in Glenoe Scots may be summarized as follows. First, irregular inflection in general requires an associative analysis for the reasons outlined in Pinker and Prince (1992); the phenomenon of family resemblances is particularly troublesome for rule-based or constraint-based analyses. Second, no rule- or constraint-based analysis can account for the fact that Lowering fails to apply in uninflected irregular verbs, but only of the [ay]-[ow] class. Third, no rule- or constraint-based analysis predicts the existence of forms like ride and wives, which are required by the associative analysis. Finally, the fact that the schemas of irregular inflection override Lowering seems to be easiest to understand if Lowering is itself a schema of a weaker sort; this last concept may be modeled by Optimality Theory, but only if many additional assumptions about associative lexicons are made.

The conclusion that as unremarkable a lexical rule as Lowering may actually be an associative schema, restricted to a specific lexicon, has potentially far-reaching consequences for the understanding of lexical phonology as a whole. How plausible would it be to extend an associative view to all of lexical phonology? Since a complete discussion of this question is far beyond the scope of this paper, I list below just some of the considerations that would be required in such a discussion. The reader interested in applying OT to lexical phonology should consider which of these are compatible with OT and which are not.

First, if the associative view of lexical phonology is correct, lexical rules must be like irregular inflection in that they hold of forms in the lexicon rather than

being applied 'on line' the way regular inflection is thought to do. This, of course, has been the view of lexical rules since their theoretical birth (see, for example, the discussion of Velar Softening in Kiparsky 1982: 34-35).

Second, like the schema that changed dived to dove, lexical rules must be only semiproductive, diffusing through the lexicon on an item-by-item basis rather than affecting all forms at once. This is also a familiar property of lexical rules (Kiparsky 1988).

Third, there should be evidence that the form classes affected by lexical rules are delineated more by family resemblances than by specific phonological properties or features. Of course, by definition a rule contains a structural description that restricts its application to specific environments. However, it is well known that lexical phonology often contains sets of very similar patterns that cannot be reduced to a single rule. For example, consider the voicing of /s/ in English (discussed, among other places, in Chomsky and Halle 1968, Rubach 1984, Halle and Mohanan 1985, Borowsky 1986, Myers 1993). This simple phenomenon occurs in all of the following frustratingly similar but nevertheless distinct environments (in some forms /s/ and /z/ are also affected by Palatalization). I have arranged the contexts in an order that makes the family resemblance clear.

(29) s-Voicing

a. V: __ V

Parisian	[cf.	Paris]
reclusion	[cf.	recluse]
design	[cf.	sign]
resist	[cf.	assist]

b. V __ \O(V,“)

diss—lve	[cf.	solve, d“ssolœtion]

c. Vk __ \O(V,“)

ex’st	[cf.	‡xis]
ex‡mine	[cf.	Ž xec te]

d. r __ V

dispersion [cf. disperse]
coercion [cf. coerce] {also with /s/}
persist [cf. insist] {also with /s/}

e. r __]

Mars [cf. Martian]

Fourth, like schemas, lexical rules should behave as if they were nonderivational. That is, they should act like generalizations that hold of forms in the lexicon rather than transformations that replace one representation by another. This point can be illustrated by the same phenomenon noted above. As the following examples show, voiced /z/ can arise in contexts sharing a family resemblance with those given in (29) but where it could not have been derived from /s/.

(30) Other cases of derived /z/

a. Derived from /t/ in the context r_V

diversion [cf. divert]

b. Derived from /dó/ in the context r_V

submersion [cf. submerge]

c. Derived from /r/ in the context V:_V

cohesion [cf. cohere]

Fifth, if lexical rules are nonderivational and distributed across the lexicon like schemas, genuine rule ordering paradoxes should abound. They do; a recent collection and review of the literature may be found in Chapter 5 of Myers (1993). Once again, s-Voicing provides an example as well. Normally, /s/ derived from /t/ by the rule of Spirantization does not undergo s-Voicing, as in relate-relation; since Chomsky and Halle (1968) this has been explained by ordering s-Voicing before Spirantization. Given this, the voicing seen in equate-equation implies a paradoxical ordering.

Finally, an associative theory of lexical phonology requires an associative theory of morphology. Pinker and Prince (1992) point to research on

morpholexical 'redundancy rules' (e.g. Jackendoff 1975, Aronoff 1976, Lieber 1980; see also Anderson 1992, Bochner 1993) as forming the groundwork for just such a theory.

It goes without saying that numerous other difficult problems must be faced before we can develop an associative theory of the lexicon that is sophisticated enough to do everything now thought to require lexical rules. I merely hope to have convinced the reader that the phenomena seen in Glenoe Scots, combined with the well-known 'lexical' behavior of lexical rules and the evidence presented by Pinker and Prince (1992) for an associative view of irregular inflection, together provide strong motivation for the adoption of an associative lexicon in a complete phonological theory.

REFERENCES

Anderson, Stephen R. (1992). *A-morphous morphology*. Cambridge: Cambridge University Press.

Aronoff, Mark (1976). *Word formation in generative grammar*. Cambridge, Mass.: MIT Press.

Bloch, Bernard (1947). English verb inflection. *Lg* 23. 399-418.

Bochner, Harry (1993). *Simplicity in generative grammar*. New York: Mouton de Gruyter.

Borowsky, Toni (1986). *Topics in the lexical phonology of English.* PhD dissertation, University of Massachusetts. Published 1990, New York: Garland.

Bybee, Joan L. (1988). Morphology as lexical organization. In M. Hammond and M. Noonan (eds.) *Theoretical morphology*. New York: Academic Press. 119-141.

Bybee, Joan L., and Dan I. Slobin (1982). Rules and schemas in the development and use of the English past tense. *Lg* 58. 265-289.

Chambers, J. K. (1973). Canadian raising. *Canadian Journal of Linguistics* 18. 113-135.

Gregg, Robert J. (1958). Notes on the phonology of a County Antrim Scotch-Irish dialect. Part I: Synchronic. *Orbis* 7. 392-406.

Gregg, Robert J. (1959). Notes on the phonology of a County Antrim Scotch-Irish dialect. Part II: Historical. *Orbis* 8. 400-424.

Gregg, Robert J. (1973). The diphthongs ᵃi and aÜ in Scottish, Scotch-Irish and Canadian English. *Canadian Journal of Linguistics* 18. 136-145.

Gregg, Robert J. (1985). *The Scotch-Irish dialect boundaries in the province of Ulster*. Ottawa: Canadian Federation for the Humanities.

Halle, Morris, and K. P. Mohanan (1985). Segmental phonology of Modern English. *LI* 16. 57-116.

Halle, Morris, and Alec Marantz (1993). Distributed morphology and the pieces of inflection. In Kenneth Hale and Samuel Jay Keyser (eds.) *The view from Building 20: Essays in honor of Sylvain Bromberger*. Cambridge, Mass.: MIT Press. 111-176.

Kaisse, Ellen M. and Sharon Hargus (1993). Introduction. In S. Hargus and E. M. Kaisse (eds.) *Phonetics and phonology vol. 4: Studies in Lexical Phonology.* New York: Academic Press. 1-19.

Jackendoff, R. S. (1975). Morphological and semantic regularities in the lexicon. *Lg* 51. 639-671.

Kiparsky, Paul (1982). Lexical morphology and phonology. In I.-S. Yang (ed.) *Linguistics in the morning calm.* Seoul: Hanshin. 3-91.

Kiparsky, Paul (1988). Phonological change. In F. Newmeyer (ed.) *The Cambridge survey of linguistics, Vol. I.* Cambridge: Cambridge University Press. 363-415.

Lieber, Rochelle (1980) *On the organization of the lexicon.* PhD dissertation, MIT.

Myers, James (1993). *A processing model of phonological rule application.* PhD dissertation, University of Arizona.

Paradis, Carole (1980). La r gle de Canadian Raising at l'analyse en structure syllabique. *La Revue Canadienne de Linguistique* 25. 35-45.

Pinker, Steven (1991). Rules of language. *Science* 253. 530-535.

Pinker, Steven, and Alan Prince (1992). Regular and irregular morphology and the psychological status of rules of grammar. *BLS* 17. 230-251.

Prince, Alan, and Paul Smolensky (1993). *Optimality theory*. Ms., Rutgers University & University of Colorado.

Rubach, Jerzy (1984). Segmental rules of English and cyclic phonology. *Lg* 60. 21-54.

Smolensky, Paul (1986). Information processing in dynamical systems: foundations of Harmony Theory. In D. Rummelhart, J. McClelland, and PDP Research Group (eds.) *Parallel Distributed Processing: explorations in the microstructure of cognition, Vol. 1.* Cambridge, Mass.: MIT Press. 194-281.

Vance, Timothy J. (1987). 'Canadian Raising' in some dialects of the northern United States. *American Speech* 62. 195-210.