Formal Property Inheritance and Consonant/Zero Alternations in Maori Verbs

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Abstract

Word-forms are organized according to two types of structure: grammatical (morphological) and phonological. In generative frameworks, this is modeled through the interplay of phonological and morphological modules. Not all phenomena in word-formation can be unambiguously assigned to one of these domains, however. This paper examines one such case in Maori, where what were originally phonologically-motivated patterns of allomorphy have arguably been reanalyzed as competing paradigms. A phonological approach is unable to capture this fact without use arbitrary devices, yet a purely morphological approach is unable to capture the degree to which the original phonological motivations for the alternations are still valid. This paper proposes to address this conundrum in a novel framework, in which the phonological and morphological attributes of word-formation are not seen as discreet modules, but as competing forces shaping the forms of words within a single formal system.

1. Introduction

Ultimately any formal grammar is a model of property inheritance; a theory of what the overarching generalizations of a language and of Language are, and how individual forms derive their properties from them. This is true for of any level of grammar, but is most interestingly so in the production of word-forms, since the generalizations they reflect derive from two sources: their morphological and phonological structure. In the modular-interactive approach to grammar espoused by Generative linguistics, this fact has led several generations of theorists to confront, in many different guises, the following question: if a morpheme, in combination with others, either undergoes or triggers an alternation in a way not predictable from its most basic surface form, should this fact be captured in the phonological or morphological side of its representation? This problem was already apparent in rule-based phonological models, but has become even more important with the development of Optimality Theory; in trying to explain alternations in terms of satisfaction of universal phonological constraints, we can see more clearly those remaining aspects of phonology which are not completely phonologically motivated.

This choice between types of explanation is often posed in terms of deciding between a somewhat abstract underlying representation and making recourse to diacritic features. This was the central question of the so-called abstractness controversy, which proposals such as Kiparsky's (1973c) Alternation Condition were intended to provide a principled answer to. The development of Autosegmental Phonology (Goldsmith 1976, Clements 1976, Anderson 1976)

and a renewed in interest in underspecification (c.f. Archangeli 1984, 1988, Archangeli & Pulleyblank 1989) in subsequent research represent another approach to the same problem, by using geometrically complex phonological representations to capture morphemes' allomorphic properties, to the extent of attempting to reducing all forms of apparently non-concatenative morphology to affixation (see for example McCarthy 1981a, Lieber 1987). Ultimately, non-linear phonological models such as these are attempts to represent diacritic properties phonologically, within an enriched theory of phonological representations.

The choice between phonological and morphological approaches to allomorphy is naturally a non-issue in theories of word formation which reject a modular divide between morphology and phonology. This has been attempted under several morphological models which attempt to annex large parts of what has traditionally been thought of as phonology, such as in Bochner's (1993) generative Lexical Relatedness Morphology, and cognitive network-based morphological models such as Bybee (1988, 1994, 1995), and Aske (1990). This approach however overlooks the importance of purely phonological structure (such as syllables), which work such as Itô (1986, 1989), Goldsmith (1990), and output-oriented frameworks such as Harmonic Phonology (Goldsmith 1993a) and Optimality Theory (Prince & Smolensky 1993, McCarthy & Prince 1993b) have convincingly argued motivates many alternations.

The first section of this paper will examine what appears to be evidence for the modular approach; the fact that some alternations are motivated completely by phonological structure, and that conversely others cannot be described in purely phonological terms, apparently requiring recourse to morphological features. Whether these are distinct types or ends of a continuum remains an open question. I will argue for the later view by examining a set of alternations in Maori verbs which previous work has found difficult to classify as either morphological or phonological (Hohepa 1967, Hale 1968, 1991, 1973, Kaye 1975, Kenstowicz & Kisseberth 1979, Kenstowicz 1981, Halle 1979, Sanders 1990, 1991, Blevins 1994). These facts will be shown to be amenable to a non-modular approach to word formation; a model of Dual-Source Property Inheritance will be proposed which draws on Lexical Network models and Bochner's model, but acknowledges that word-forms are shaped by phonological constraints as well as morphological organization.

2. Alternations and the Phonological/Morphological Continuum

2.1 A Purely Phonological Alternation

It is incontrovertible that many alternations can best be described in terms of phonological environments. But, given that we might formulate a morphological model which

can make reference to phonological generalizations (cases such as the limitation of the English inflectional comparative and superlative to minimally-sized adjectives argue for the necessity of this), we can still ask whether any alternations are motivated purely by phonological structure. Answers to this question have usually been based on simplicity-based arguments (Carrier 1979:24-31, Kiparsky 1982, Kenstowicz & Kisseberth 1979:179-204), but since formal parsimony can only be measured within the context of a specific grammatical model, such arguments are ultimately not as convincing as empirical facts.

One good place to look for such facts is in diachronic developments where a change in the shape or use of a morpheme destroys the original environment for an alteration, and the alternation resists the opportunity to grammaticize into a morphological marker in its own right. One example which has been discussed by Kenstowicz & Kisseberth (1979:170) involves the process of final obstruent devoicing in German. As can be seen in the examples below, the addition of a suffix -/ə/ in the traditional declension of certain nouns allows an underlying voicing contrast to emerge in final consonants which is neutralized in uninflected forms; but in more colloquial varieties where this ending is lost (as part of a general tendency to drop final schwa) final devoicing is reimposed.

Bare Noun	**Traditional Dative Sg.**	**Colloquial Dativ Sg**.	
di:p	di:bə	di:p	‘thief’
hunt	hundə	hunt	‘dog’
ta:k	ta:gə	ta:k	‘day’
blu:t	blu:tə	blu:t	‘blood’
rɔk	rɔkə	rɔk	‘skirt’

If the voicing alternations in ‘thief’, ‘dog’ and ‘day’ were really part of the inflectional process, we might expect them to have grammaticized into a sort of final-consonant mutation system, parallel to the development of the voicing alternations found in few English word pairs such as /bæθ/-/beyð/, /layf/-/layv/, /haws/-/hawz/, etc. The fact that this did not happen seems to indicate that the German voicing alternations are part of an independent phonological structure.

2.2 Limits of the Phonological Approach

Purely phonological approaches to alternation, ones in which claim that all the covert allomorphic properties of a morpheme can be captured in a purely phonological representation, find their greatest challenge in languages which have done precisely what German has not.

Proponents of non-linear models have made strong claims to the effect that all known types of 'process morphology' ranging from umlaut to reduplication can be reduced to affixation in a suitably enriched phonological framework, a finding which would validate a purely affixation-based theory of morphology (see in particular Lieber 1992 for an expression of this view, and Anderson 1992 for a critique). Although appealing, this approach has proven incapable of accounting for certain alternations, supporting the view that some allomorphy is triggered morphologically, either as a morphological rule proper or through a phonological rule triggered by a morphological feature. One problem which has proven particularly intractable to the purely-phonological approach is the initial consonant mutations of Celtic languages.

Lieber (1983,1987) proposes an autosegmental theory of mutation which assumes the following: (1) Mutation-triggering morphemes consist of (in addition to their segmental content, which may be null) unassociated autosegments containing the features associated with that mutation. (2) Mutable segments are unspecified for those features which alternate between their base form and their mutated form(s). Segments (and classes of segments) which do not undergo a certain mutation may be prespecified for those features. (3) Floating mutation features associate with unspecified segments whenever possible, but do not override prespecified ones; i.e., mutation is feature-filling rather than feature changing. (4) Default rules specify the values for features which have not been filled by floating mutation features (i.e., unmutated segments).

This proposal makes a number of testable claims. First, it claims that a mutable consonant must be consistent in which features it alternates in. Second, it claims that a mutation may assign a consonant a marked value for a feature (that is, the one other that would be specified by the default rule), but cannot change a segment underlyingly specified for the marked value back to the unmarked; although markedness may be language-specific, this still entails that no language may have one mutation which changes +F segments to -F, and another which changes -F to +F. Ball & Müller (1992) and Kibre (1997) have demonstrated that Lieber's account of consonant mutation in Welsh is unworkable because the language's mutation system does not obey the first these constraints. The Breton dialect of Île de Groix, as described by Ternes (1970), presents an even clearer counterexample by violating both constraints. A set of relevant forms is presented below (from Ternes, p216):

Base Noun	**'his N'**	**'her N'**	**'your.PL N'**	
pen	iben	xifen	xupen	'head'
to:l	ido:l	xizo:l	xuto:l	'table'
či	ĭji	xixi	xučі	'dog'
kroxen	igroxen	xixroxen	xukroxen	'pelt'

brøj	ivrøj	xibrøj	xuprøj	‘brother’
duwern	izuwern	xiduwern	xutuwern	‘hands’
ǰẅeilaj	iẅeilaj	xiǰẅeilaj	xučẅeilaj	‘bed’
grãn	ixrãn	xigrãn	xukrãn	‘grain’
mam	ivam	ximam	xumam	‘mother’

The three morphemes /i/, ‘his’, /xi/, ‘her’, and /xu/ ‘your.PL’, each of which is representative of many others, trigger a set of alternations in stem-initial consonants (or word-initial in the usual orthography, which treats these pronouns as independent words), termed Lenition, Spirantization (or Aspiration) and Provection. Lieber’s model’s prediction of unidirectionality of mutation is clearly refuted by Lenition and Provection, which respectively cause the voicing of voiceless stops (in /pen/, /to:l/, /či/, /kroxen/) and devoicing of voiced ones (in /brøj/, /duwern/, /ǰẅeilaj/, /grãn/). Its prediction that mutable consonants alternate in a consistent set of features is confounded by the effects of Lenition and Aspiration. Observe that Lenition is a chain process, causing the voicing of voiceless stops but the frication of those which are already voiced; Lieber has proposed to represent Lenition in Welsh (which is identical in the relevant attributes) as a floating pair of features [+voice, +continuant], and account for the failure of underlyingly voiceless stops to ‘double lenite’ by becoming [+continuant] as well as [+voice] by prespecifying them as [–continuant]. But in both languages voiceless stops do become fricatives under Spirantization/Aspiration.

Lieber has proposed that this problem can be avoided by representing Spirantization/Aspiration as a floating [+aspirated] autosegment rather than [+continuant], and changing aspirated stops to continuants by a later, ‘low level’ rule. Assumedly, the conflict between Groisillon Breton Lenition and Provection could be similarly resolved. But this approach effectively turns phonological features into diacritics (the traditional cymriological term “Aspiration” is a historical accident; representing the mutation with [+breathy voice] or a floating high tone would be just as principled a choice); it suggests that morphemes’ mutation-triggering characteristics might be more honestly represented as morphological features (as Ternes in fact did), and leads us to conclude that the underlying hypothesis of the autosegmental approach is wrong: not all covert allomorphic properties can be captured in phonological representations, no matter what their complexity.

Autosegmental approaches to mutation-like processes have re-emerged in Optimality Theory, particularly in the theory of floating features and segments proposed by Zoll (1993, 1996). It is possible to replace Lieber’s use of underspecification with constraints and achieve slightly more palatable results, but ultimately leading to the same conclusion. Under an OT

approach, we could propose that floating mutation features do associate in a structure-changing way (overriding underlyingly associated features), and try to account for the quirks of the system through judicious constraint ranking. Following Zoll, we could assume various constraints which are satisfied by the realization of floating features, termed PARSE-FEAT constraints, which we will need one of for each mutation. Then, for example, we can account for voiceless stops' ability to absorb [+continuant] under Spirantization but not Lenition by ranking a faithfulness constraint, satisfied if voiceless stops retain their underlying continuancy, above PARSE-FEAT(Lenition) but below PARSE-FEAT(Aspiration).

This approach might be made to work, although it uses a fairly idiosyncratic and language-particular conception of faithfulness constraints. However, it does not really escape the need for mutation types to be lexically marked, since the constraint hierarchy crucially refers to them, and thus reaffirms our initial conclusion: the mutation affects associated with prefixes in Île de Groix Breton cannot be represented in terms of purely phonological representations. The facts of this language, and by extension word-formation theory in general, require a mechanism for phonological alternations to be triggered by non-phonological (morphological or diacritic) contexts.

3. Verb Alternations in Maori

The contrast between cases such as the German and Breton alternations discussed above appears to lend support to the modular view of word formation. Yet the modular view only follows if these can be shown to be distinct types, rather than extremes of a continuum. In this section I will examine a set of alternations in Maori verb forms which are considerably more ambiguous. Previous studies (Hohepa 1967, Hale 1968, 1991, 1973, Kaye 1975, Kenstowicz & Kisseberth 1979, Kenstowicz 1981, Halle 1979, Sanders 1990, 1991, Blevins 1994) show marked disagreement (and in some cases, honest uncertainty) whether a morphological or phonological approach is best suited to this problem, suggesting that an escape from this dichotomy would be desirable.

3.1 The Alternations

The alternations in question derive from a restructuring of the syllable in the common ancestor of Polynesian languages, such that formerly tolerated consonantal codas were disallowed and dropped. Several vowel-initial verbal suffixes allowed root-final consonants to survive in certain morphological contexts, however, and in the passive and gerundive forms of modern Maori verbs allow a consonant to emerge which is unexpressed in the uninflected form.

Base Form	**Passive**	**Gerundive**	
afi	afitia	afitaŋa	‘embrace’
mahue	mahuetia	mahuetaŋa	‘leave’
mea	meatia	✓	‘say’
(pu)puri	puritia	puritaŋa	‘hold’
hopu	hopukia	hopukaŋa	‘catch’
tomo	tomokia	tomokaŋa	‘pass in/out’
aru	arumia	arumaŋa	‘carry’
inu	inumia	inumaŋa	‘drink’
mau	mauria	mauraŋa	‘seize’
tau	tauria	tauraŋa	‘come to rest’
fao	faofia	faofaŋa	‘put in’
wero	werohia	werohaŋa	‘stab’
(ti)tiro	tirohia	tirohaŋa	‘look’

(Forms are taken from Biggs 1969, Hale 1973, Sanders 1990, 1991, Bauer 1993, Blevins 1994, and two Maori dictionaries, Williams 1957 and Ryan 1974. The orthographic and quasi-orthographic representations of some of these sources have been retranscribed according to Bauer’s phonemic system; the chief substitutions are /f/ for *wh* and /ŋ/ for *ng*).

Although the central interest of this paper is the form of Passives and Gerundives, some statements are in order about their function. The Maori passive, while it does serve the usual valence-changing function of passives (Shibatani 1985, 1988, Shibatani & Thompson 1996), can apply to intransitive as well as transitive verbs, and is used significantly more commonly than the English passive, particularly in the past tense (Bauer 1993:398-406). The gerundive form seems to serve both as a derivational verb-nominalization process, as in /ekeŋa/, ‘voyage’ < /eke/, ‘embark’, and as a means of nominalizing an entire clause, arguably a more inflectional process since it is required by certain syntactic constructions (ibid., p510), a range of functions not unlike the English gerundive[1].

[1]Note that in Maori dictionaries, the Passive form of a verb is generally listed in the main entry, but Gerundive forms are usually only listed when they are at least partly lexicalized, and as a separate entry. I have drawn extensively on dictionaries for the Gerundive examples in this paper, so it should be kept in mind that most of them have some kind of lexicalized meaning, but could assumedly also function as an inflection of the corresponding verb in syntactic frames calling for the Gerundive.

Consonant/zero alternations are not the only type of allomorphy found in the passive and gerundive of Maori verbs. First, since a majority of common Austronesian roots were already vowel-final before the loss of final consonants, it is not surprising that many Maori verbs form the passive and gerundive without the emergence of a covert consonant. These verbs are sometimes passivized by the addition of -/ia/ and -/aŋa/, more often by the reduced forms -/a/ and -/ŋa/.

Base Form	**Passive**	**Gerundive**	
mahi	mahia	mahiŋa	‘work’
faaŋai	faaŋaia	faaŋaiŋa	‘foster’
hui	huia	huiŋa	‘gather’
kite	kitea	kiteŋa	‘see, find’
moe	moea	moeŋa	‘sleep’
heke	hekea	hekeŋa	‘descend, migrate’
haŋa	haŋaia,haŋaa	haŋaŋa	‘build’
rapa	rapaia, rapaa	rapaŋa	‘seek’
runa	runaa	runaŋa	‘draw together’
noho	nohoia	noho(h)aŋa	‘sit’
koko	kokoa	kokoŋa	‘corner’ ☑
patu	patua	patuŋa	‘strike, kill’
ehu	ehua	ehuaŋa	‘bail out’ ☑

Sanders (1990) has proposed that the variation between -/ia/ and -/aŋa/ on the one hand and -/a/ and -/ŋa/ is predictable: the fuller forms are added to verbs ending in /a/ and /o/, and the reduced set are added to stems ending in other vowels. This generalization seems to be partially correct; as far as I have been able to determine, verbs ending in /i/, /e/ and /u/ only take -/a/. But /o/-final stems show nearly as strong a preference for the reduced passive, with only an occasional exception like /noho/; furthermore, following /a/, both types seem to be possible, and the variation seen in /haŋa/ and /rapa/ is frequent.

Use of the non-reduced gerundive does not necessarily parallel that of the non-reduced passive. In verbs ending in short vowels, such as the examples above, its use seems to be rare and

idiosyncratic. However, Blevins (1994:48) observes that after long vowels either type of gerundive can be used[2]:

Base Form	**Passive**	**Gerundive**	
kii	kiia	kiiaŋa, kiiŋa	‘say’
too	tooia	tooaŋa, tooŋa	‘drag’
ruu	✓	ruuaŋa, ruuŋa	‘shake’

Another type of allomorphy is found in verbs which form Passives and Gerundives with the consonants /n/ and /ŋ/. Instead of forms with -/nia/, -/naŋa/, -/ŋia/, -/ŋaŋa/, examples such as the following are found:

Base Form	**Passive**	**Gerundive**	
uta	utaina	utaŋa	‘load’
puta	putaina	putaŋa	‘appear’
wera	weraina	✓	‘burn’
ako	a(a)kona	aakoŋa	‘teach’
kaa	kaaŋia	kaaiŋa	‘burn’ ✓
tohu	tohuŋia	tohuŋa	‘keep’
eke	ekea, ekeŋia	ekeŋa	‘climb, mount, embark’
uu	uuŋia	uuŋa	‘reach land’
kai	kaiŋa	kaiŋa	‘eat’
aro	aroŋia	aroŋa	‘turn’
waha	wahaŋia, wahatia, wahaa	wahaŋa	‘carry on back’

The generalizations covering these forms are as follows. Verbs associated with a latent /n/ form the passive by adding -/ina/ if the last vowel is /a/, otherwise by adding -/na/; they form gerundives by adding -/ŋa/. Verbs associated with a latent /ŋ/ passivize by adding -/ŋia/, unless the verb ends in /i/, in which case the ending is -/ŋa/; they form Gerundives by adding -/ŋa/. The phenomena at work can be described as metathesis (-/ina/ instead of -/nia/) and ‘haplology’:

[2]Blevins writes that elision *is* obligatory in monosyllabic stems with long /aa/. However, her one example is ambiguous and I have been unable to find any other data on this point, so I will omit this exception from my account.

expected sequences of the type /{n,ŋ}aŋa/ are reduced to /ŋa/, and possibly also in the deletion of the Passive's /i/ in /akona/ and /kaiŋa/ (Biggs 1961, McCarthy 1981b). But again there is some variation. It should also be noted (contra Sanders 1990:138) concerning haplology that /naŋa/ and /ŋaŋa/ sequences are found in Maori, as in /faŋaŋa/, 'arm span measure', even in derived environments such as the forms /haŋaŋa/ and /runaŋa/ listed earlier, where -/ŋa/ is added to a surface form ending in /na/ or /ŋa/.

One last group of verbs form passives with less generalizable allomorphy, such as /taakaa/-/taakaakina/, 'break', /mea/-/meiŋa/, 'make' (used in causative constructions).

3.2 Distributional Factors

The distribution of the passive and gerundive types is not at all even. Bauer (1993:397) reports that the number of verbs forming passives other than with -/a/, -/tia/, and -/ŋia/ is relatively small, and in a count of passive types in a Maori dictionary (Williams 1957), Sanders (1990) found -/a/ and -/tia/ listed for 41.09% and 31.1% of verbs respectively; no other type accounted for more than 4.5% or 6.6%, depending on how they were grouped[3]. The predominance of -/tia/ over other consonant+/ia/ forms is noteworthy for the extent to which it is out of proportion to the overall frequency of /t/ in Maori; in a small sample of texts Biggs (1961) found that /t/ accounted for 9.08% of all phonemes, not significantly more than /k/ (8.6%), which Sanders found in only 1.9% of passives.

In light of these facts Hohepa (1967) has proposed that the forms -/tia/ and -/taŋa/ have been reanalyzed as the default forms of the passive and gerundive, a hypothesis for which Hale (1968, 1973) offers a number of intriguing pieces of evidence. The claim has been contested by Sanders (1991, 1990), who also refutes some of Hale's factual points. Blevins (1994) on the other hand suggests that /t/ based variants do have a default status, but only with a prosodically-defined subclass of the Maori lexicon. On the whole, I think the case for default status of -/tia/ and -/taŋa/ is convincing, and will review the relevant facts here.

Hale's evidence comes from cases where verbal morphology is added to stems which are not (basically) verbs, and from the inflection of verbs in situations where a "correct" passive or gerundive form is not known, or somehow blocked; in both cases forms with /t/ predominate. An

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[3]In contrast to Bauer's claim, -/ŋia/ did not prove to be particularly frequent (3.9%). However, Bauer notes that certain dialects regularly replace -/tia/ with -/ŋia/, and assumedly -/ŋia/ is highly frequent in these varieties of Maori.

example of the first type arises from the fact that when clauses are passivized or nominalized, certain adverbs "agree" with the verb by taking passive or gerundive endings; as in the examples below, these are always -/tia/ and -/taŋa/[4].

/kite/, 'see' + /noa/, 'indeed' + passive → /kitea noatia/ 'just seen' (Bauer 1993:357)

/aroha/, 'love' + /nui/, 'big' + passive → /arohatia nuitia/, 'dearly loved' (p399)

/fiu/, 'punish' + /paakaha/ + gerundive → /fiuŋa paakahataŋa/, 'severe punishing' (p48)

/taŋi/, 'cry' + /hotuhotu/, 'sobbingly' + gerundive → /taŋihaŋa hotuhotutaŋa/ 'sobbingly crying'[5] (p48)

/patu/, 'hit' + /pokerehuu/, 'without cause' + /noa/ 'without conditions' + passive → /patua pokerehuutia noatia/, 'was hit without rhyme or reason' (Blevins 1994:37).

In several other constructions, verbal morphology is applied to stems which are basically nouns. One of these V+N compounding, or object incorporation, (see Bauer 1993:478-79 for discussion of the construction, and Mithun 1984 for a typological discussion of the construction type). When verbs derived by this process are passivized or nominalized, marking is applied to the entire form (rather than the verbal head), and generally -/tia/ or -/taŋa/ is selected. An example is /mate/, 'lack' + /kai/, 'food' + gerundive → /matekaitaŋa/ (Bauer 1993:48). In another (not terribly productive) construction, nouns are derived from other nouns by adding a gerundive ending, which is always -/taŋa/: /kawana/, 'governor' → /kawanataŋa/, 'government'; /kiiŋi/, 'king' → /kiiŋitaŋa/ 'kingdom'; /maaori/, 'Maori' → /maaoritaŋa/ 'Maori culture'. Another case is found when nouns are used as verbs in spontaneous discourse; in passive contexts -/tia/ is used, as in /faretia/, from /fare/, 'house' (Hale 1991:99), /porotia/ from /poro/, 'butt end', and /raahuitia/ from /raahui/, 'flock, bundle' (Blevins 1994:35). Sanders (1991:160) observes that not all applications of passive and gerundive morphology to non-verbs make use of

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[4]In Bauer's presentation the words in question are parsed as noa-tia, etc. To maintain a more theory-neutral presentation as to the morphological structure of these words, I have removed morpheme boundary marks throughout.

[5]These are not Bauer's translations. The examples are extracted from complete sentences corresponding to a variety of English constructions, so for simplicity I have tried to isolate the meaning of the individual words in question.

Also note that Bauer glosses /hotuhotu/ as 'sob', but dictonary translations indicate an adverbial meaning, and this seems to be what is intended from Bauer's description.

/t/-varieties; for example the derivative of /mate/, ‘dead’ meaning ‘death’ is not */matetaŋa/ but /mateŋa/, but Bauer has pointed out (p398) that all of Sanders’ examples involve stems which are used elsewhere as verbs, and might be expected to maintain their verbal allomorphic characteristics[6].

Blevins (1994) has noted a third construction where verbal suffixes can be added to originally non-verbal roots involving the causative prefix /faka/-, which can be added to any open-class root. Verbs derived by prefixing /faka/- to nouns and adjectives show a very strong tendency towards the forms -/tia/ and -/taŋa/, as in the examples below (p36).

Noun or Adjective	**Passive of Derived Causative**
atamira, ‘stage, platform’	fakaatamiratia, ‘laid out on a stage’
maaori, ‘Maori’	fakamaaoritia, ‘translated into Maori’
koopeke, ‘cold’	fakakoopeketia, ‘made cold’
maroke, ‘dry’	fakamaroketia, ‘made dry’

The /t/-based passive and gerundive forms are also applied to basically verbal stems in a number of ways which strongly suggest a default status. One of Hale’s more intriguing claims is that causative verbs derived with the prefix /faka/- take -/tia/ in the passive even if derived from a verb which by itself selects some other form. Sanders (1990:159) gives several counterexamples, but Blevins has found other cases consistent with Hale’s claim; a few examples of both types are listed below.

Base Verb	**Passive**		**Causative**	**Passive**	
ara	arahia	‘get up’	fakaara	fakaarahia	‘raise’
noho	nohoia	‘sit’	fakanoho	fakanohoia	‘set’
ŋaro	ŋaromia	✓	fakaŋaro	fakaŋaromia	‘destroy’
hua	huaina	‘name’	fakahua	fakahuatia	‘pronounce’
taakaro	taakarohia	‘play’	fakataakaro	fakataakorotia	‘amuse’
koopee	koopeeŋia	‘squeeze’	fakakoopee	fakakoopeetia	‘squeeze’

It is not clear which pattern predominates, or whether the preservation of a stem’s passive through /faka/-prefixation is predictable; since Maori allows zero-derivation to some extent, it is

[6]More specifically, they belong to a class of stems termed “universals” in Maori studies, which function either as nouns or verbs.

also possible that some of these cases were actually derived from nouns or adjectives rather than directly from verbs. Thus it is unclear how strong an argument these facts make for the default status of -/tia/, although they clearly provide at least some support.

Hale also notes several cases where -/tia/ is applied to verbal stems apparently by default, such as that the -/tia/ based form is generally used in English borrowings, that it is used when basically nominal roots are used as verbs in spontaneous speech, and that it can be used in place of other passive endings when the conventional one is forgotten. The regular use of -/tia/ in borrowings is confirmed by Bauer (p398), although she does note that there are exceptions. Bauer also concurs that -/tia/ 'can be used in cases of doubt as to the correct ending', although in some dialects -/ŋia/ is preferred (assumedly these are the same dialects which regularly substitute -/ŋia/ for -/tia/).

Sanders (1991:162) contests the claim that -/tia/ is frequently used in place of other forms on the grounds that although many verbs allow free variation between several passive forms, -/tia/ is often not among them; under the assumption that morphological variation tends to represent the replacement of an idiosyncratic form with a default one, we would expect frequent alternations between -/tia/ and some other form if Hale's claim is correct. Sanders cites few examples, but is certainly correct in asking whether mentalist claims about speakers' memory or certainty can be validated in their actual behavior, so to investigate this claim I have made an informal survey of this type of variation. A short Maori-English dictionary (Ryan 1974) was searched for verbs listed with multiple passive forms; of the 24 found, 42% has -/tia/ as one of them. Whether or not this is a strong enough showing to substantiate Hale's claim is left up to the reader, although it should be kept in mind that variation between an idiosyncratic and default form is not the only kind found in morphology; lexemes may show variation between competing marked forms, as in English verbs such as /'spriŋ/, /'ʃriŋk/, and /'stiŋk/ which appear to be migrating from the three-form paradigm of /'siŋ/-/'sæŋ/-/'sʌŋ/ towards the pattern of /'swiŋ/-/'swʌŋ/ (see Bybee & Slobin 1982, Bybee & Moder 1983). Finally, we should bear in mind that the spontaneous replacement of an accepted form with another may be distinct from the lexicalized variation which is recorded in dictionaries, and needs to be studied in real discourse.

A final argument against the default status of -/tia/ and -/taŋa/ to be considered is Sander's finding (Sanders 1991:165), noted above, that verbs which add no consonant at all are the most numerous type. (Sanders also suggests that consonant-less forms of the passive and gerundive have the highest token frequency; while I have no reason to doubt this, his corpus of example sentences from a dictionary is probably too far removed from actual language use to really demonstrate this). Yet Maori would not be the first known case where what appears to be a

default morphological pattern has a lower frequency than marked alternatives; two cases which have been examined in previous literature are the Arabic 'sound plural' and the German -/s/ plural (see, McCarthy & Prince 1990 and Clahsen et al. 1992, respectively, and Prasada & Pinker 1993 and Bybee 1995 for discussion).

There are also reasons why speakers might tend to favor /t/-based forms over consonant-free ones as a default. First, whereas the forms -/tia/ and -/taŋa/ are completely regular, consonant-free forms make an additional distinction between full and reduced variants which we have seen is not totally predictable. A second complexity is that, because of haplology, the reduced form (the more common variety) of the consonant-less gerundive is identical to what would be expected from a verb which introduced an -/n/- or -/ŋ/- in the passive. Given a verb whose bare form ends in -/a/ and whose gerundive ends in -/ŋa/, there is no way to predict whether its passive will be -/aa/, -/aina/, -/aŋa/, or -/aia/.

Blevins (1994) offers different view of these facts based on her discovery of a correlation between the prosodic shape of verb roots and the form of their passive and gerundive. Consonant-free forms seem to be preferred in bimoraic roots, but disfavored in larger ones (monomoraic roots are not allowed). In a search through a Maori dictionary (Biggs 1990), 95% of verbs passivized with -/tia/ were trimoraic or longer; among verb stems with consonant-free passive forms 78% were bimoraic, and 14% were trimoraic or longer but analyzable as compounds. Furthermore, the mora-counting generalization is applied with striking regularity in English borrowings, as in the examples below (Blevins 1994:40-41).

Base Verb	**Passive**		**Base Verb**	**Passive**	
wepu	wepua	'whip'	haafe	haafetia	'halve'
kiki	kikia	'kick'	pooti	pootitia	'vote'
kihi	kihia	'kiss'	purei	pureitia	'play'
pati	patia	'patch'	miraka	mirakatia	'milk'
kape	kapea	'copy'	waea	waeatia	'wire'
pine	pinea	'pin'	puruuma	puruumatia	'sweep'

Blevins proposes to account for this by designating both consonant-free forms and /t/-based forms defaults in the domains of bimoraic and larger roots respectively, although an exception must be made for non-verbal roots, which always take -/tia/ regardless of their size. This last condition suggests a slightly different interpretation: that /t/-based forms are the true default, while consonant-free inflections are a marked pattern which is nevertheless fairly productive in bimoraic roots. The consonant-free forms would then have a status somewhat

analogous to the ablaut in English /'striŋ/-/'strʌŋ/ (except for ranking higher on a scale of productivity), which has a strong presence in verbs matching a certain schema, as seen in its diachronic expansion to /'sniyk/ and speakers' tendency to apply it to conforming nonce-forms such as /'spliŋ/ (again see Bybee & Slobin 1982, Bybee & Moder 1983).

Whether consonant-free inflections are treated as a second default pattern or a marked but moderately productive competitor is only a meaningful distinction in theories of morphology which draw a categorical boundary between regular and irregular morphology. In any case it seems clear that any adequate account of Maori must capture the fact that /t/-based forms are the ultimate 'elsewhere' case for passive and gerundive marking, and that consonant-free forms are a strong competitor in the domain of bimoraic roots.

4. Previous Approaches

If the rule types represented by German final devoicing and Île de Groix Breton mutation are distinct, we will naturally want to categorize the allomorphy of Maori verbs as one or the other. But as will become apparent in the discussion below, neither approach is entirely satisfactory; a purely diacritic model is unable to capture significant phonological generalizations, but a number of quirks in the system make it impossible to formulate a completely adequate account without recourse to morphological features.

4.1 Diacritc Approaches

In the earliest Generative treatment of Maori, Hohepa (1967) proposes a morphological approach to passive and gerundive allomorphy, analogous to what seems to be called for in the case of Île de Groix Breton consonant mutation. Under this model the basic form of the passive is /tia/, and verbs taking other forms are marked with features which trigger rules to change /tia/ into /hia/, /a/, /mia/, /ina/, etc. Hohepa does not address the gerundive but the approach could obviously be extended to it. Likewise, if we wished to emend Hohepa's account in light of the prosodic regularities discovered by Blevins, we could make -/a/ and -/ŋa/ the default forms for bimoraic roots, and deal with exceptions by allowing bimoraic roots to be marked for /t/-forms and longer ones to be marked for consonant-free ones. There are a number of possible formulations of this basic approach. One perhaps more typical than Hohepa's use of morphologically-triggered phonological rules would be through a battery of morphological rules, i.e. 'the passive is marked by -/kia/ if a verb has feature *x*, by -/hia/ if a verb has feature *y*… elsewhere by -/tia/'.

The real problem with the morphological-feature analysis is that it fails to capture phonological regularities in the allomorphy of the Maori passive and gerundive. First, there is the system-internal generalization that the two consonants seen in passive allomorphs but omitted in their corresponding Gerunds, /n/ and /ŋ/, fall into the natural class of non-labial nasals. There are also selectional regularities, such as the fact that -/ia/ is only affixed to verbs ending in /a/ and occasionally /o/, and that only -/ina/ and -/na/ are restricted to verbs ending in /a/ and verbs not ending in /a/, respectively. Most importantly, the morphological approach fails to connect the emergence/deletion of consonants to the fact that Maori phonotactics bans coda consonants in general.

4.2 Phonological Rule-Based Approaches

These facts suggest that, distributional generalizations aside, a phonological approach to this problem might be most appropriate. A number of such models have been proposed in previous literature, which will be reviewed below; notably, however, complete descriptive adequacy does not seem to be possible without some recourse to diacritic features.

Given the basic facts of Maori verb forms described in 2.3, and no information on the distribution of the different patterns, a straightforward generative approach to the matter of the lexically specified consonants which arise in the passive and gerundive is to postulate that Maori verbs may have underlying final consonants, that the passive and gerundive are marked by the affixation of -/ia/ and -/aŋa/, and that word- or syllable-final consonants are deleted by a rule or some other process. This approach in fact predates Generative Phonology, as can be seen in Bloomfield's (1933) discussion of cognate alternations in Samoan: "Samoan, which permits no final consonants at all, … therefore has sets of alternations like the following: [tani], 'weep', [tanisia], 'wept'; [inu], 'drink', [inumia], 'drunk'; [ulu], 'enter', [ulufia], 'entered'. It is clear that a useful description will here set up the basic forms in theoretical shape, as [tanis, inum, uluf]." As is clear in Bloomfield's description, this approach captures the insight that these alternations derive from the absence of word- or syllable-final consonants in the language as a whole.

A derivational generative approach to Maori along these lines has been formulated by Hale (1968, 1973) (who I should point out does not actually endorse it) and revised by McCarthy (1981b) and Sanders (1990). All of these studies assume slightly different sets of rules, but seem to converge on four basic processes.

Truncation: Word-final consonants are deleted (common to all versions).

Metathesis: Morpheme-final non-labial nasals metathesize with a following front vowel if (a) the nasal is /n/ and the preceding vowel is [+back], or (b) the nasal is /ŋ/ and the preceding vowel is /i/[7].

Elision: Subject to blocking in non-derived environments, a vowel is deleted after another vowel[8], except for /i/ after /a/.

Haplology: A sequence of a non-labial nasal followed by /aŋa/ reduces to /ŋa/.

Truncation captures the general lack of word-final consonants in Maori, and eliminates underlying final consonants from uninflected verbs. Elision accounts for the fact that the passive and gerundive, taken to be underlyingly -/ia/ and -/aŋa/, surface as -/a/ and -/ŋa/ in most verbs with no associated (underlying) final consonants. Metathesis accounts for passives of verbs such as /tua/, 'fell' → /tuaina/, which are taken to end with an /n/ underlyingly; furthermore, if Metathesis is ordered before Elision, passives such as /tahu/, 'keep' → /tahuna/ and /kai/, 'burn' → /kaiŋa/ can be derived from underling root forms /tahun/ and /kaiŋ/ via intermediate forms /tahuina/ and /kaiiŋa/. Haplology, finally, accounts for the fact that roots which are surmised to end in /n/ and /ŋ/ by their passives (such as the last two mentioned) form gerundives with -/ŋa/ rather than -/naŋa/ and -/ŋaŋa/.

No actual generative account of Maori has achieved this level of simplicity, primarily because Elision applies in an unpredictable set of verbs. Sander's (1991:154) contention that Elision is obligatory after "after high or front vowels" seems to be largely true, but Elision does apply after /o/ and sometimes after /a/ as well, albeit unpredictably: thus we have /noho/, 'dwell' → /nohoia/ but /koko/, 'corner' → /kokoa/, and frequently free variation after /a/. Earlier formulations (Hale and McCarthy), noting that no verbs form passives and gerundives with -/pia/ and -/paŋa/, proposed that verbs which do not undergo Elision end with an underlying /p/,

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[7]Sanders (1990:154) attempts to unify these conditions as follows "Morpheme final non-labial nasals metathesize with a following front vowel when the nasal is preceded by a vowel that differs from it in backness". This formulation is too broad, however, since metathesis does not occur where /ŋ/ is preceded by /e/, as in /ekeŋia/. A possible reformulation might be "morpheme-final non-labial nasals metathesize with a following front vowel when preceded by a vowel which differs from the nasal in backness, and if the nasal is [+high], is also [+high].

[8]In the works being cited, this rule is generally formulated along the lines of "Morpheme-initial vowels have no phonetic realization" (Sanders 1990:354). Framing the rule a cyclic one within Lexical Phonology, as I have done here, buys us the morpheme-initial constraint for free, and allows Metathesis to feed Elision (as described below) without assuming the somewhat troublesome definition of morpheme initial (something like "originally morpheme initial") implicitly assumed by Sanders.

deleted by an additional rule of morpheme-final /p/-deletion ordered after Elision. But this approach abandons the degree to which Elision is predictable (that is, it is an arbitrary fact that verbs can end in underlying -/op/ and -/ap/, but not -/ip/, -/ep/, -/up/). Furthermore, some version of Sander's vowel-sensitive approach seems to be needed if we want to account for the preservation of (metathesized) /i/ with stem-final /an/ but not other V+/n/, which seems to parallel the retention of /i/ (usually) when -/ia/ is added to /a/-final verbs by accounting for /i/-deletion in both cases with one Elision rule with the same exceptions; McCarthy's analysis is forced to divide Elision into three separate rules.

Probably the best solution is a partial recourse to diacritic features. The facts presented can be adequately accounted for by formulating Elision more or less as above, with the added exception that it applies optionally to /a/ after long vowels in order to account for /kiiaŋa/~/kiiŋa/ etc., and allowing eliding /a/-final and non-eliding /o/-final verbs to be marked as exceptions. Since the number of exceptions in either direction is not terribly large, this is a reasonable solution; it does, however, undermine the claim that Maori verb alternations can be accounted for under a completely phonological analysis.

Haplology presents another problem, although one which can probably be worked around. As has been noted, -/naŋa/- and -/ŋaŋa/- sequences are found in Maori, even in derived environments in the Gerundives of verbs whose base forms end in -/na/ and -/ŋa/, such as /haŋaŋa/ from /haŋa/, 'build'. One way to work around this problem is to order Haplology before Elision, so that at the point where Haplology might apply, a form like /haŋaŋa/ will still have the representation /haŋaaŋa/. I don't personally find this solution too insightful, but it does work. Morpheme-internal -/naŋa/- and -/ŋaŋa/- can be exempted by restricting Haplology to derived environments.

The biggest objection to the phonological rule-based approach, which initially led researchers to consider alternatives, is that is fails to capture the default status of the forms -/tia/ and -/taŋa/, or the secondary prominence of consonant-free forms in bimoraic roots. To account for the regular use of /t/-based forms when verbal morphology is added to adverbs, we would have to mandate through some kind of morpheme structure condition that all adverbs underlyingly end in /t/. In fact, to account for the regular use of t-forms in those cases where verbal morphology is added to nouns and adjectives, we would have to extend this principle to them as well—even, apparently, to N's and A's which are not generally used in this way, just in case they ever are. Following a similar critique of abstract underlying representations leveled by Crothers (1971) and Zimmer (1975), we can ask the following question about such an analysis:

given that a Maori-speaking child would first have to learn the generalization that non-verbs always take -/tia/, and -/taŋa/, would he or she have a motivation to postulate the more abstract analysis that non-verbs end in an underlying /t/? Unless evidence can be found that speakers actually *prefer* abstract analyses, we must conclude that the answer is no.

4.3 An Autosegmental Model

Blevins (1994) proposes a non-linear phonological approach to Maori verb inflection which does a considerably better job of addressing the default status of /t/-based and consonant-free verb forms than previous linear models. The essence of Blevin's proposal is as follows:

Floating Consonants: If a verb derives passives and gerundives with a consonant other than /t/, this consonant is present in the morpheme's phonological representation, but as a floating melody element not associated with a C node.

Consonant-Free Forms: If a root has no floating consonant, and is prosodically minimal (bimoraic), it forms the passive by affixing -/ia/ and -/aŋa/.

Consonant-Based Forms: Elsewhere the default forms are C+/ia/ and C+/aŋa/, where C is an empty consonant position on the timing tier.

Linkage and Default Filling: When C+/ia/ or C+/aŋa/ are suffixed to a verb with a floating consonant, the consonant associates to the empty C node and is phonetically realized. If the verb has no floating consonant, the C position is filled by /t/, the default consonant in the language (the default consonant may differ in certain dialects, such as the one discussed earlier which generally replaces /t/-based inflections with forms with /ŋ/).

Exception Marking: Larger-than-minimal roots can be marked as exceptionally taking consonant-free forms.

Allomorphy: Rules of Metathesis, Elision and Haplology are applied as in the preceding rule-based analyses.

Blevin's analysis is subject to the same difficulties in the formulation of Haplology and Elision discussed earlier, and probably also requires a minor diacritic to help the latter rule distinguish between /nohoia/ and /kokoa/. In capturing the default status of /t/-based forms and secondarily consonant-free forms, it is definitely more adequate; for example, the treatment of borrowings noted earlier (passivized with -/a/ if bimoraic, -/tia/ if longer) is predicted by this

model, but not by previous phonological accounts. It is still not completely phonological, however; it uses at least one diacritic feature, as well as reference to morphological class features. There is also one other quirk which should be noted: for the small set of bimoraic roots which take -/tia/ and -/taŋa/, Blevins proposes that a /t/ is underlyingly present to trigger the use of C+/ia/ and C+/aŋa/, rather than filled by default as in other forms with -/tia/ and -/taŋa/. Ultimately this is equivalent to the use of another diacritic feature.

4.4 Constraint-Based Approaches?

It is interesting to consider whether and how a rule-based phonological approach such as the one presented earlier could be reformulated in an optimality-theoretic approach. As originally conceived (c.f. Prince & Smolensky 1993), the constraints of optimality-theoretic phonology are instantiations of phonological universals, and the rules of the model above translate into constraints to an extent corresponding to their phonological naturalness.

The effects of Truncation can clearly be achieved by ranking NO-CODA above PARSE (see Itô & Mester 1994 for more recent discussion of syllable wellformedness constraints; for a different constraint-based approach to the related consonant/zero alternations in Samoan see Bird 1995). Elision can be accomplished by a high ranking of OCP for the feature [+syllabic], and the preservation of /i/ after /a/ (usually) might possibly explained in such an analysis, since /a/ is the one vowel in Maori which shares no vowel features with /i/. This can be formulated by stating that PARSE is outranked by the conjunction of a violation of OCP for the feature [+syllabic] and a violation of OCP for any of the features [high, low, back]. On the other hand, though, the Gerundive's /a/ is deleted after stem-final /i/, which would seem to kill this analysis. The exceptional behavior of monosyllabic roots' Gerundives, where the unreduced -/aŋa/ is often used, might be attributable to a minimal size constraint; Itô & Hankamer (1989) and Orgun (1992), Inkelas & Orgun (1995) have reported that inflected words in Turkish are required to be disyllabic, and we could either attribute the non-reduced gerundive to a similar "trisyllabic minimal size constraint" or else use a bisyllabic constraint and designate final consonants as extraprosodic.

The remaining processes have less direct translations, if any. Haplology can be motivated by the OCP, since it eliminates series of consonants sharing the features [+nasal, –labial]; however, it is not clear to me what if any combination of constraints will make deletion of an entire syllable the optimal way of satisfying it (Yip 1995a, 1995b discusses cases of morphological haplology; her proposals are not immediately applicable). An additional problem is that the rule-ordering proposed above to prevent the over-application of Haplology will of

course be unavailable in an OT analysis, so it is not clear how forms like /haŋaŋa/, the gerundive of /haŋa/, can be made exempt from the process. Metathesis might be accounted for if we can think of some reason why /in/ sequences should be preferred over /ni/, although I am not aware of any such constraint at this point, and describing which vowels may precede the metathesized /i/ might prove tricky to formalize. Maori Haplology and Metathesis are difficult to motivate from universal principles and seem to require the arbitrary rewriting power of the traditional generative rule formalism. This phonological unnaturalness ultimately suggests that these alternations belong as much to morphology as phonology.

Two last issues which a non-derivational analysis would need to consider is the restriction of certain alternations (all but Truncation) to derived environments, and the implementation of exception-marking diacritics; it seems likely that standard approaches to such issues in Optimality Theory will eventually be settled, although at this point this has not yet been resolved (see Kenstowicz 1994, Orgun 1994, Orgun (1996)☑).

5. Connectionist and Network Morphological Models

In the preceding discussion, I have contrasted various phonological approaches to Maori verbs with a "morphological" approach, which can be sketched as follows (more or less after Sanders 1990:152):

$\text{VERB}_{\text{Psv}} \rightarrow \text{VSTEM+PSV}$

$\text{VERB}_{\text{Ger}} \rightarrow \text{VSTEM+GER}$

$\text{VSTEM} = \text{hopu}_{\text{Class I}}; \text{inu}_{\text{Class II}}; \text{tohu}_{\text{Class III}}; \text{afi}; \text{puri}$

$\text{PSV} = \text{kia} /]_{\text{Class I}} \_\_; \text{mia} /]_{\text{Class II}} \_\_; \text{ŋia} /]_{\text{Class III}} \_\_ ; \ldots \text{elsewhere tia}$

$\text{GER} = \text{kaŋa} /]_{\text{Class I}} \_\_; \text{maŋa} /]_{\text{Class II}} \_\_; \text{ŋa} /]_{\text{Class III}} \_\_; \ldots \text{elsewhere taŋa}$

The approach is objectionable, as we have noted, because it misses the obvious generalizations that passive and gerundive forms of a class always (except for verbs like /tahu/-/tahuna/-/tahuŋa/) start with the same consonant (or no consonant), that the rest of the suffix following this consonant is consistently /ia/ and /aŋa/, or at least /a/ and /ŋa/, that the choice between complete and reduced consonantless forms is semipredictable from the stem-final vowel, and the phonological regularity of haplologic gerundives. A diacritic approach essentially claims that Maori speakers treat these forms as arbitrary, rote-learned paradigms analogous to

Latin declensions, and either do not analyze them further or at least do not make further analysis part of their grammar.

The conundrum is essentially that as distasteful as the diacritic analysis may seem, no phonological approach we have examined has completely escaped it, falling back either on diacritics themselves or rather abstract phonological elements (such as the never-realized final /p/ proposed to prevent the reduction of -/ia/ to -/a/ in some verbs) which are really notational variants; furthermore, none of them except for Blevins' is able to capture the t-default phenomenon. But the diacritic approach hardly exhausts the range of possible morphological models. A number of studies in morphology have examined the ways in which specific morphological patterns may derive features from more general schemata, and in this section I will review proposals form a variety of frameworks and their applicability to Maori verb forms. I will argue that such an approach allows most of the obvious parallels of these forms to be captured. However, I will also argue that this more enlightened morphological approach still misses one fundamental insight of phonological approaches, namely that the alternations involved are ultimately motivated by the phonological structure of the language, particularly syllable structure.

5.1 Redundancy in Generative Grammar

The proposals made in the models reviewed in this section draw on ideas which have been floating around in generative theory for some time, and before diving into their more radical implementations it seems appropriate to discuss their roots.

The essential notion of property inheritance developed in the following discussion has its roots in the concept of lexical redundancy rules (Jackendoff 1975, Aronoff 1976, Chomsky 1970). Under this view, word-formation rules have two functions: to describe actual speech-time processes, such as (in most cases) regular inflection, and to describe regular relationships between learned word forms, prototypically in derivational morphology. In the latter function, word-forms are stored but analyzed, and the relationships described by rules are assumed to help speakers structure their internal lexicon and store information more efficiently. As Bochner (1993) observes, this move entails a reanalysis of the basic notion of "simplicity" in evaluating grammar. Rather than rating grammars according to the total number of symbols they contain, we must tolerate redundant information in the lexicon if it is captured by a rule, and rate grammars and representations according to the amount of independent information they contain. The redundant application of morphological rules also implies a similar function for phonological ones, at least in rule-based phonological models; if the application of -/itiy/ in

/vænitiy/ describes a lexical relation rather than an on-line process, then the same must be true for Trisyllabic Laxing.

In some Generative work we also find some hints of an idea which is more fully explored in Bochner's work, that rules may act in a redundancy-capturing capacity across other rules as well as static lexical entries. Along these lines, Anderson (1992) proposes a class of "metarules" to account for several sorts of phenomena in morphology. These include cases where a language uses the same forms for a variety of unrelated meanings (for example, the affixes -/z/ and -/d/ in English), or has an inventory of formally similar devices, as in German's proclivity for umlaut, ablaut and miscellaneous other vowel-change processes. Meta-rules, "which formalize redundancies over the Word Formation Rules of a language" (p346), are also applicable where a single rule has developed idiosyncrasies in different contexts, allowing us to view each version as an independent but still capturing the shared characteristics between them.

5.2 PDP Approaches

The shift from a symbol-counting to an independent-information measure of simplicity is essentially an admission that the brain stores information differently than human-devised systems such as digital computers or paper and ink. Past and present proponents of this move have generally motivated it by the argument that its predictions are borne out in the structure and evolution of word-formation systems (for example in the grammaticization of phonological alternations), and by appeal to intuitions about memory and the mind (everyday experience supports the hypothesis that information is easier to remember if analyzed). However, little research within formal linguistics has questioned what underlying cognitive processes shape symbolic systems in this fashion. Parallel-Distributed Processing (a.k.a. neural-net) computational models of cognition (Rumelhart et al. 1986) and related models may offer insight here, particularly in that they describe knowledge representations as both distributed and overlapping.

PDP approaches were first applied to problems of word formation in Rumelhart & McClelland's (1986, 1987) model of English past tense inflection, a simple feed-forward network which learned to associate representations of present tense verb forms with their corresponding pasts. As noted by critics (Pinker & Prince 1988, Pinker 1991, Lachter & Bever 1988, Sproat 1992), this early model is probably better viewed as an exploration of the potential of connectionist networks than as a serious model of word-form production in language users, but successive models (Plunkett & Marchman 1991, MacWhinney & Leinbach 1991, Cottrell & Plunkett 1991, MacWhinney 1994, Daugherty & Seidenberg 1994) have adopted an architecture

more closely paralleling the speaker's task, using networks which take tense and verb-identity as input and produce verb forms in either tense as outputs. Other researchers (Gasser & Lee 1990, Gasser 1992, 1996) have proposed recurrent-network models which, rather than producing a complete output form in one pass, learn to associate tense and lexeme inputs with the production of a string of phonemes in sequence, explicitly incorporating the temporal dimension of word-form production.

The implications of this approach to the current discussion are most explicitly presented in Stemberger's (1985, 1992, 1994) non-computationally-implemented but psychologically explicit connectionist word-formation model. Stemberger's model envisions three levels of units: meaning units, with semantic and inflectional features, words units, and phonemes. Regularities are captured by "gangs", collections of representations which share characteristics and which therefore are mutually-activating. Gangs have different strengths, depending on their frequency of use; regular patterns have strong gangs, which can be activated independently of individual lexical items (explaining, for example, the ability of regular inflections to apply to non-phonologically-canonical stems, as in English /'rʌmbəd/), while irregular patterns are captured by gangs which are closely associated with (only activated in conjunction with) specific lexical items or shared characteristics of those items.

What is most interesting to us right now about models like Stemberger's is that they describe a kind of underlying mechanism which predicts the intuitions about memory which make the notion of redundancy rules make sense. In such models a complex lexical item can be stored, but to the degree that its properties are paralleled in others, a gang describing that pattern will assume some of the work for its storage. Under this view, redundancy rules describe ways in which different words' representations *overlap*, and as the computational side of PDP research has shown, this type of organization is one which networks can create spontaneously in the learning process.

5.3 The Lexical Network Model

Another type of network-based approach is the lexical-network or schema approach to word-formation first proposed for irregular forms in Bybee & Slobin (1982) and Bybee & Moder (1983), and since developed into a general approach to word-formation in Bybee (1988, 1994, 1995). This approach, while not explicitly modeling the kind of subsymbolic processing described by the PDP model, assumes a similar associative type of underlying memory structure. Like the PDP model, it proposes that words entered into the lexicon are related to other words via sets of lexical connections between identical or similar phonological and semantic features.

Another claim, not generally discussed in PDP linguistic literature but compatible with the framework is that words' and schemas' representations have different strengths depending on their token frequency. Bybee further proposes that whether a pattern or schema will apply to new lexical items is dependent on its phonological and semantic generality and lexical strength, which together produce a characteristic of "autonomy", somewhat analogously to Stemberger's claim that the productivity of a pattern is represented by its gang's ability to be activated independently of specific lexical items.

The Lexical Network model goes beyond what has been done in other connectionist paradigms in studying the nature and structure of the schemas themselves, and their interaction in complex word-formation systems, in addition to their cognitive underpinnings. Schemas are described as either relational, describing both a base and derived form (more or less analogous to a traditional morphological rule), or product-oriented, describing only a target form. The regular English past -/d/ is representative of the first type, whereas the irregular pattern in /'brɔt/, /'bɔt/, /'kɔt/, /'sɔt/ is clearly product-oritented since the base forms /'briŋ/, /'bay/, /'ketʃ/, /'siyk/ have no shared formal features (but Bybee 1995:431 notes that in zero-marked pasts like /'kwit/, which always end in /t/ or /d/, -/d/ affixation also seems to function in a product-oriented schema and is satisfied by the form of the stem).

Schemas have been applied successfully to a number of problems which traditional rule-based approaches have found difficult. Aske (1990) examines accent in Spanish nouns, which is usually governed by a simple rule "accent the last stem syllable if it is closed, otherwise the penult", but has clusters of exceptions such as words formed with the suffix -/iko/~/ika/ which are almost always proparoxytonic; Aske proposes that this can be described directly by a set of schemas which apply with different levels of generality. Köpcke (1988, 1993) demonstrates that pluralization of German nouns, although generally accomplished with apparently derivational processes such as suffixation and umlaut, can be more directly described in terms of product-oriented schemas.

A similar if more intricate case is presented by pluralization in Hausa, the subject of an insightful schema-based treatment by Haspelmath (1989). Hausa nouns undergo a wide inventory of formal changes when pluralized, making a traditional rule-based approach extremely difficult to formulate. However, Haspelmath demonstrates that the system makes sense if viewed from the perspective of its outputs, which conform to one of several patters. For example while singular-plural pairs such as the following are idiosyncratic in the changes involved,

Singluar	**Plural**	
kàntii	kántúnàa	‘store’
záurèe	záurúkàa	‘porch’
kûnnée	kúnnúwàa	‘ear’
tákòobí	tákúbàa	‘sword’
táfki	táfúkàa	‘pond’

in each case the output conforms to a schema -/ú/+C+/àa/.

Haspelmath takes the schema approach to word-formation one step further with the observation that the set of plural schemas postulated for Hausa share certain formal characteristics and routes for achieving them, which can be thought of as defining a sort of metaschema, analogous to Anderson’s metarules[9].

5.4 Lexical Relatedness Morphology

In the preceding discussion we have seen increasing awareness of the notion that statements of regularity in a language’s word-forms correspond to both processes and storage organization. In traditional generative approaches, this has taken the form of reanalyzing what rules mean, an acceptance that even if they are formally derivational rules may actually correspond to static organization. In PDP and lexical network models, this insight has inspired a complete reformulation of the word-formation process from the ground up. We have also seen, tentatively in Anderson’s discussion, explicitly in Haspelmath’s, and at least potentially in other network models, that there may be multiple levels of redundancy relationships; that is, redundant aspects of rules should be captured by more rules, in the same way that rules capture parallels between sets of derived forms.

This idea is most fully developed in Bochner’s (1993) Lexical Relatedness Morphology. The principles of this model are outlined below.

- A language’s morphology consists of an inventory of words in a language, plus a set of relational rules (describing relations between surface word-forms, rather than

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[9]Rosenthall (1995) proposes another account of Hausa (apparently without knowledge of Haspelmath’s paper), which is set in Optimality Theory and therefore also output-oriented, in a different way. Rosenthal argues that Hausa plural forms are (in part) motivated by prosodic minimality constraints (McCarthy & Prince 1990), but does not address the issue of how different patterns associate and/or share representations. Ultimately, both aspects may be required in a complete account of Hausa; the Dual-Source Inheritance model proposed below might be a good approach for incorporating them.

between a surface form and an underlying one) to capture information which is redundant across multiple word-forms (see also Jackendoff 1975).

- Words do not have internal constituent structure (i.e., morphemes), other than prosodic units such as syllables. Words only have morphological structure in the sense that parts paralleled by other words are recognized as such.

- A word can be partially described by a rule without being a perfect fit. "Mismatching" can occur semantically or formally. For example *information* can be linked to other nouns described by the rule $X_V \leftrightarrow Xeyʃən_N$, even though it does not describe the process of *inform*ing, and /iy'kweyʒən/ can be partially described by $Xeyt_V \leftrightarrow Xeyʃən_N$ even though it has /ʒ/ instead of /ʃ/.

- The "cost", or of a representation depends on the degree of independent information, i.e. information not captured by rules, needed to describe it[10].

- Shared aspects of relational rules are captured by other, more general rules.

Bochner does not explicitly discuss the underlying cognitive processes which would derive these principles, but they are in accordance with the proposals of PDP and Lexical Network approaches. If we assume a neural-network or similar system as a kind "cognitive substrate" to Bochner's symbolic system, these principles follow; we can think of rules as capturing the degree to which lexical items have overlapping storage, and the notion that independent information has a "cost" in terms of memory load has a direct implementation.

Although formulated as a theory of morphology, LRM allows phonologically regular patterns to be captured within word-relation rules, and Bochner proposes that all non-allophonic alternations should be absorbed into morphology in this way. How phonological regularities can be captured in morphological representations can be illustrated with the partial Latin paradigms below (this discussion follows that of Bochner 1993:120-134 with some minor deviations).

1sPres	**2sPres**	**3sPres**	**1pPres**	**2pPres**	**3pPres**	
amo:	ama:s	amat	ama:mus	ama:tis	amant	'love'

[10]Bochner (p43) proposes an approach to calculating a numerical value of this cost, based on information theory (see Bar-Hillel 1964), but only goes as far as sketching it. This is probably wise inasmuch as the relationship between information theory and cognition remains fairly murky, and we can only use the former as a very rough guideline for understanding the latter.

laudo:	lauda:s	laudat	lauda:mus	lauda:tis	laudant	‘praise’
rego:	regis	regit	regimus	regitis	regunt	‘rule’
du:ko:	du:kis	du:kit	du:kimus	du:kitis	du:kunt	‘lead’

It is questionable whether any truly phonological alternations are at work here, however the recurring “theme vowels” /a:/ and /i/ are phonological regularities which need to be accounted for. Generative analyses have sometimes treated these vowels as regular elements of the stem (see Harris’ 1987 analysis of Spanish), i.e. ‘love’, ‘praise’, ‘rule’ and ‘lead’ are underlyingly /ama:/, /lauda:/, /regi/, and /du:ki/. However, a number of facts argue for the traditional word-and-paradigm view (see Hammond & Noonan 1988) that they belong to the endings. One is that only /a:/, /e:/, /e/, and /i/ can be theme vowels. Another is that theme vowels are deleted, altered, shortened or replaced in many forms (such as the 1s Present) which cannot be attributed to regular phonological processes. In traditional analyses this conclusion is problematic, because it means that verbs with different theme vowels must be classified as different conjugations with independently-stored sets of endings, so that a range of obvious generalizations such as the consistency of the theme vowel in a given conjugation, and the parallels between the post-theme material in different conjugations, and in where the theme vowel emerges are treated as coincidental and/or synchronically irrelevant.

Under the LRM approach, this paradox does not arise. The paradigms above can be analyzed in a bottom-up fashion, as follows: first, rules are formulated to capture the parallels between verbs within each paradigm, as below. Note that relational rules, unlike derivational rules, have no inherent limitation to refer to only two forms, and that x ↔ y ↔ z is formally equivalent to the separate statements x ↔ y, x ↔ z, and y ↔ z; that is, a set of two-term rules over which transitivity applies (see Bochner 1993:40-41, 120-124, who uses slightly different but equivalent notation).

Latin 1st Conjugation Present Paradigm Rule:

$Xo:_{V1s} \leftrightarrow Xa:s_{V2s} \leftrightarrow Xat_{V3s} \leftrightarrow Xa:mus_{V1p} \leftrightarrow Xa:tis_{V2p} \leftrightarrow Xant_{V3p}$

Latin 3rd Conjugation Present Paradigm Rule:

$Xo:_{V1s} \leftrightarrow Xis_{V2s} \leftrightarrow Xit_{V3s} \leftrightarrow Ximus_{V1p} \leftrightarrow Xitis_{V2p} \leftrightarrow Xunt_{V3p}$

Next, a more general rule is formulated to describe the parallels between these ones. (Following Anderson’s terminology I will label such rules “metarules”, to distinguish them from ones which apply directly to word-forms).

Latin Present Paradigm Metarule:

$Xo:_{V1s} \leftrightarrow XVs_{V2s} \leftrightarrow XV_{V3s} \leftrightarrow XVmus_{V1p} \leftrightarrow XVtis_{V2p} \leftrightarrow XVnt_{V3p}$

In both cases there is some mismatch; the theme vowel /i/ is replaced by /u/ in the 3P Present, and /a:/ is shortened in the 3S and 3P; this adds slightly to their cost, but still allows the overall patterns to be learned. Individual paradigm rules can be thought of as "inheriting" properties from metarules. This conception is closely related to the object-oriented paradigm of computer programming, exemplified by languages such as SmallTalk and C++, in which object classes (complex data types with associated procedures) can be derived from other, more general classes.

These phonological regularities are ones which many phonologists would be willing to write off as morphology anyway, but some may object to this type of analysis for phonological regularities in general, particularly for those which arise in a variety of morphological contexts. For example, we can say that /iylæs'tisitiy/ is related to /iy'læstik/ by a rule $Xk_{Adj} \leftrightarrow Xsitiy_{N}$, which is partly derived from $X_{Adj} \leftrightarrow Xitiy_{N}$, but we will need to make similar subrules for other suffixes which cause velar softening to explain words like /kə'θalisizəm/. However, LRM does not deny the possibility that some morphological generalizations may refer completely to phonological content, and allows that individual rules may inherit properties from more than one general rule. Thus, in this example, we would want to posit that English has both a velar-softening+/itiy/ rule and a velar-softening+/izəm/ rule, but we would also claim that the redundant features of these are captured by a generalized velar softening rule, $Xk \leftrightarrow Xsi$ (as well as affixation rules). Aside from its nonderivational aspect, this initially appears to be just a translation of the traditional generative phonological rule formalism; however, such rules' reanalysis as "allomorphy redundancy rules" entails a number of theoretical simplifications over traditional phonological approaches.

- Since morphophonemic redundancy rules only "apply" as components of more specific morphological rules, the characteristic of blocking in non-derived environments, an issue over which considerable ink has been spilled in largely unsuccessful attempts to find an explanation internal to phonology (Kiparsky 1973a, Kaisse & Shaw 1985, Inkelas 1990, 1993, Kiparsky 1982, 1993), is predicted automatically.

- Whereas the above would be equally true of a derivational model in which phonological processes were incorporated into morphological ones, such a model would have no natural way of describing non- or post-cyclic rules. The relational nature of rules in LRM allows them to characterize post-cyclic rules just as easily as cyclic ones. For example, for a paradigm rule which relates a bare form to inflected

ones (schematically, X ↔ XY ↔ XZ), a subrule can be postulated in which the "bare" form is subject to allomorphy. For example, in a language which raises final /e/ to /i/, we could have a paradigm Xi ↔ XeY ↔ XeZ; the parallel between this rule and others where raising is evident could be captured by an allomorphic redundancy rule sensitive to word-final environments.

- The relational aspect of LRM rules also makes it possible to describe phonologically regular alternations without being forced to decide which alternant is an basic or underlying when none has a clear claim on this status, as is often the case in vowel-harmony systems.

- Under an LRM analysis, the grammaticization of phonological alternations into non-concatenative morphology does not involve the kind of discrete jump required in modular systems. Under most models a general assumption is that (Anderson 1992:340) "as new generations of speakers confront the task of learning the language, they continue to look for phonological bases for variation, but increasing opacity may obscure this sufficiently that a set of morphological conditions is more accessible". In the LRM model, however, an alternation is treated as part of its triggering morphological processes as soon as it becomes contrastive. The transformation can be seen a gradual process in which the motivating environment becomes obscure, so that the alternations' presence in a given word-formation rule is arbitrary, followed by attrition of the originally affixational part of the rule.

These are strong arguments for the LRM model. In the following section, I will demonstrate that it can be used to formulate an account of Maori verb alternations with is descriptively adequate. However, I will argue that the purely morphological approach it advocates makes for an analysis which is not theoretically adequate in one respect, that it does not link formal alternations to the aspects of purely phonological structure which motivate them.

5.5 Application of the LRM Model to Maori

An application of the LRM approach to the Maori data we have been looking at is a straightforward matter. Although our first pass will still suffer from one of the failings I have indicated is inherent to any purely morphological approach—an inability to link alternations to their motivations in purely phonological structure—it arguably does a better job of describing the alternations involved within a consistent framework than any of the proposals which we have reviewed so far.

An LRM description of Maori can be proposed which is analogous to the treatment of Latin paradigms presented above, with "theme consonants" instead of theme vowels. Essentially, we will treat each verbal pattern as a kind of paradigm; thus we will have the following collection of rules:

First, there are rules for the verb patterns which add C+/ia/ and C+/aŋa/.

The t-, k-, m-, r-, f-, and h-Paradigm Rules:

$X_V \leftrightarrow Xtia_{VPsv} \leftrightarrow Xta\eta a_{VGer}$

$X_V \leftrightarrow Xkia_{VPsv} \leftrightarrow Xka\eta a_{VGer}$

$X_V \leftrightarrow Xmia_{VPsv} \leftrightarrow Xma\eta a_{VGer}$

$X_V \leftrightarrow Xria_{VPsv} \leftrightarrow Xra\eta a_{VGer}$

$X_V \leftrightarrow Xfia_{VPsv} \leftrightarrow Xfa\eta a_{VGer}$

$X_V \leftrightarrow Xhia_{VPsv} \leftrightarrow Xha\eta a_{VGer}$

Next, there are rules for the verbs which take consonant-less passives and gerundives. The most typical, reduced forms, can be represented by the rule below.

The No-C Paradigm Rule:

$X_V \leftrightarrow Xa_{VPsv} \leftrightarrow X\eta a_{VGer}$, where X = μμ

For now, at least, the deletion of suffix-initial vowels has to be treated as mismatching.

Note that this rule incorporates the generalization that the paradigm is particularly popular for bimoraic roots. This means that bimoraic roots which use this paradigm will be particularly easy to learn, but that larger roots which use it will be more costly because there is mismatching.

As we have noted, the non-reduced consonant-free forms do not really form a paradigm, so it is most appropriate just to represent them as isolated rules (and as we have noted, paradigm rules are equivalent to sets of two-term rules subject to transitivity). To the extent that their distribution is predictable from the shape of the stem, this should be represented in the rules:

The Unreduced No-C Passive Rule:

$Xa_V \leftrightarrow Xaia_{VPsv}$

The Unreduced No-C Gerundive Rule:

$X_V \leftrightarrow Xa\eta a_{VGer}$, where X = CVV

Of course, there are exceptions to the conditions on both, verbs which take -/ia/ and -/aŋa/ even though they do not match the usual templates. In these cases, we will have to think of the derived forms as mismatches, which are more costly to learn than perfect matches to the rules but still partially described by them.

Next we turn to verbs which introduce /n/ and /ŋ/ in the passive. We have noted that these verbs consistently take just -/ŋa/ in the gerundive, and that the passive's /i/ is subject to metathesis after /a/ in n-verbs, deletion in other n-verbs, and deletion after /i/ in ŋ-verbs. These variations all call for separate paradigm rules.

The n-Paradigm Rule:
$XV_{V} \leftrightarrow XVna_{VPsv} \leftrightarrow XV\eta a_{VGer}$, where V ≠ a

The a+n-Paradigm Rule:
$Xa_{V} \leftrightarrow Xaina_{VPsv} \leftrightarrow Xa\eta a_{VGer}$

The ŋ-Paradigm Rule:
$XV_{V} \leftrightarrow XV\eta ia_{VPsv} \leftrightarrow XV\eta a_{VGer}$, where V ≠ i

The i+ŋ-Paradigm Rule:
$Xi_{V} \leftrightarrow Xi\eta a_{VPsv} \leftrightarrow Xi\eta a_{VGer}$

There is a bit of redundancy across these formulations, in that the a+n-Paradigm Rule is written to specifically apply to stems with -/a/, and the general n-Paradigm rule is written specifically for stems not ending in /a/, while the same relationship holds between the ŋ-Paradigm and i+ŋ-Paradigm Rules. I do not believe there is anything in LRM as currently formulated which can help us avoid this, but we might accomplish this by incorporating something akin to the Elsewhere Condition of Generative frameworks (Kiparsky 1973b), reformulated in terms consistent with the model below:

Elsewhere Condition:
Where there are two rules such that one is a proper subset of the other, learning the use of the more general rule in contexts where the more specific is applicable incurs a greater cost than learning to use the more specific rule.

This will allow us to simplify the n- and ŋ-Paradigm Rules to:

The n-Paradigm Rule (Assuming Elsewhere Condition):
$X_V \leftrightarrow Xna_{VPsv} \leftrightarrow Xŋa_{VGer}$

The ŋ-Paradigm Rule (Assuming Elsewhere Condition):
$X_V \leftrightarrow Xŋia_{VPsv} \leftrightarrow Xŋa_{VGer}$

Note that this makes the a+n-Paradigm and i+ŋ-Paradigm rules into subrules of the revised n-Paradigm and ŋ-Paradigm rules. Thus the cost of learning the more specific rules is only as great as the extent to which they diverge from the more general ones. The effect of the Elsewhere Condition will be that the competing a+n-Paradigm and i+ŋ-Paradigm Rules will be preferred where applicable; that is, learning to use the general n-Paradigm Rule for -/a/ final stems or the ŋ-Paradigm Rule for ones in -/i/ will be costly. (To an extent corresponding to the productivity of the competing, more specific rules).

Now let us consider how the recurring patterns across these specific paradigm rules may be captured by more general rules. First of all, at the top level, we will want to posit a general affixational redundancy rule:

Passive and Gerundive Affixation Metarule:
$X_V \leftrightarrow Xia_{VPsv} \leftrightarrow Xaŋa_{VGer}$

With some mismatching, the reduced No-C Paradigm Rule can be derived from this rule directly. Similarly, the essentials of the Unreduced No-C Passive and Unreduced No-C Gerundive rules are already present verbatim within this paradigm rule; their restriction to /a/-final and monosyllabic roots, respectively, is new information, but the essential changes produced are already present verbatim within the metarule above, and are inherited cost-free. The t…h-Paradigm Rules involve a consistent type of mismatching, in which an identical consonant is inserted in the passive and gerundive, so these should be derived from the general affixation rule via an intermediary which expresses this regularity:

Consonant Paradigm Metarule:
$X_V \leftrightarrow XCia_{VPsv} \leftrightarrow XCaŋa_{VGer}$

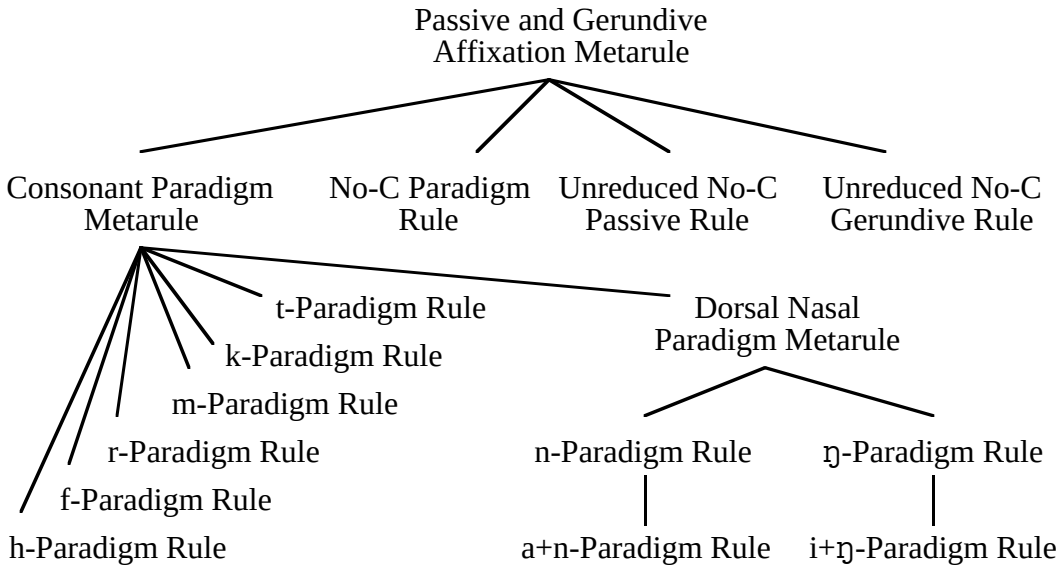
The n-, a+n-, ŋ-, and i+ŋ-Paradigm Rules can also be derived from the Consonant Paradigm Metarule, with a greater degree of mismatching. But noting that they involve a consistent type of mismatching in their gerundives, the absence of an expected syllable which has been termed haplology, we can formulate an intermediate representation to capture this:

Dorsal Nasal Paradigm Metarule:

$X_V \leftrightarrow XC_{+nas,-lab}ia_{VPsv} \leftrightarrow X\eta a_{VGer}$

We can sketch the inheritance relationships between the paradigm rules sketched above in a kind of family-tree, as below:

Inheritance Relationships Between Maori Paradigms:



It is clear that the LRM approach escapes our first objection to the diacritic approach to Maori verb-types, in that it directly captures the formal parallels between paradigms and elements of paradigms. It is no longer just a coincidence that passive forms all end in -/(i)a/ and Gerundives in -/(a)ŋa/, or that verbs which insert a consonant in one inflection (except in the case of /n/) insert the same consonant in the other. At the same time, it makes it possible to capture the distributional facts which provided the original impetus for a morphological approach. Although each of the twelve primary paradigm rules has the same formal relationship to the verbs it describes, we can, following Bybee and other connectionist frameworks, think of this relationship as having a different cognitive status in each case depending on the pattern's distribution. First of all, each pattern has a lexical strength relative to its token frequency. We have seen that two patterns, the t-paradigm and the reduced no-consonant paradigm, are considerably more frequent than other patterns and these will have correspondingly greater lexical strengths.

The fact that the reduced no-consonant passive applies in borrowings suggests that it has some degree of autonomy; that is, its representation has an existence somewhat independent from

(or, in more connectionist terminology, which can become activated independently from) those of the words it is used with. However, the fact that it never applies to non-verbs suggests that its autonomy is incomplete. The t-Paradigm Rule, for which we have seen ample evidence of generalizability and productivity, is highly autonomous. We can surmise that verb forms with -/tia/ and -/taŋa/ are often not stored at all, but produced on the spot as a speech-time process, which is consistent with its reported use as an alternative to other forms.

In comparison with the phonological models we have considered, the current proposal fares reasonably well although it does not capture all of the regularity they are able to extract. An important advantage is that the LRM model's tolerance for "mismatching" allows us to capture imperfect generalizations which are problematic for generative approaches. For example, the fact that non-reduced no-consonant verb endings have distributions which are only partially predictable by stem-final vowels does not force the use of abstract segments or diacritics. Verbs like /noho/ which take the "wrong" form do not need to be marked [-eliding] or represented as /nohop/ or some other fantasy; their use of the unreduced no-consonant forms is simply a little more costly to learn than in the case of verbs which conform perfectly (and is possibly subject to leveling).

The LRM model formulated so far demonstrates what a sophisticated morphological approach to Maori verb alternations might look like. Unlike the diacritic model usually described as "the morphological alternative" to phonological-rule analyses, it is able to capture a great deal of regularity in the forms of the passive and gerundive. On the other hand, I maintain that no version of the LRM model is able to link allomorphy to its ultimate motivation in phonological structure. Following the next section, I will argue for a novel approach to word formation which can remedy this.

6.0 Dual-Source Inheritance

The LRM approach to Maori consonant/zero alternations proposed so far is descriptively adequate. It is arguably more elegant than any of the competitors examined so far in that it accounts for all the facts within a single formalism, the inheritance of properties from redundancy rules. However, since it does not account for the phonological motivation for the alternations, it really only tells half of the story.

In section 2 of this paper, I examined what word-formation theory has generally taken to be two discrete types of alternations. On the one hand, German final obstruent devoicing is a sterling example of an alternation motivated completely by phonological structure; within

Optimality Theory it can be succinctly and adequately described by positing an underlying final voicing contrast and ranking a constraint against voiced coda obstruents over PARSEFEAT(voice). On the other hand, Brythonic Mutation defies truly phonological explanation entirely. In a traditional Generative analysis, it must be described by rules sensitive morphological/diacritic features. In an LRM analysis, it can be described as part of the process which adjoins the associated particle or affix; to the extent that different morphemes share the same mutations, this can be captured by morphophonemic redundancy rules which describe types of alternations but have no specification for their environment.

Maori falls somewhere between these two cases. The substance of the preceding discussion can basically be described as attempts to make it conform to models of one or the other type. Rule-based phonological analyses such as that proposed most forcefully by Sanders are ultimately claims that, if viewed at an abstract enough level, Maori verb alternations are fundamentally the same kind of process as German final devoicing, while the diacritic approach proposed by Hohepa and Hale claims that it is more akin to Breton mutation. Both Blevins' model and the LRM model formulated in the last section can be viewed as attempts to bridge this divide from one side or the other. Autosegmental and "non-linear" models are ultimately theories of how to represent diacritic features within phonological forms, while the allomorphic redundancy rules of Bochner's model allow phonological regularities to be captured within morphology. But despite the descriptive success of this last approach, I maintain that a complete account of these facts must tie them to their ultimate motivations in phonological structure.

In this section, I will argue that there is an alternative to the "annexational" approach to the problem of alternations which are ambiguously morphological and phonological. Rather than trying to expand the domain of one module at the expense of the other, I will propose a model in which word-forms inherit properties from both domains within a unified formal framework.

6.1 Dual-Source Inheritance: Principles and Simple Examples

The model proposed here utilizes a formal system drawn primarily from two sources: Bochner's LRM model and constraint-based phonological theories such as Optimality Theory. The machinery of the model is essentially that of LRM, but can also be viewed as an extention of some ideas which have recently emerged in optimality-theoretic work. I will go about introducing the new model by surveying this work, and proceding to what I claim is its logical conclusion.

Optimality Theory (Prince & Smolensky 1993, McCarthy & Prince 1993b) makes two principle claims. The first is that the phonological structure of any language can be characterized

in the ranking of a universal set of constraints on possible forms and on input-output faithfulness, and the second is that phonological influences on word-structure can be described by descending this ladder of constraints and recursively weeding output candidates which violate them. Generally, these claims are implemented more or less as follows:

Morphology: Form an underlying representation by concatenating strings of phonemes (i.e., morphemes).

Gen: Generate all possible output strings.

Eval: Descending a language-specific ranking of constraints, discard violating output candidates until only one remains (or until no constraint distinguishes between members of the remaining pool, in which case free variation is assumed to result).

- One type of constraint (phonotactic) describes preferred of desired phonological shapes (or more typically the inverse, i.e. classes of phonological shapes which are dispreferred).

- Another set places value on consistency between the output candidate and the input string (originally Termed faithfulness constraints, now possibly subsumed in McCarthy & Prince's 1995 broader theory of Correspondence).

Other mechanisms beyond these typically-cited components of the theory may be implicitly present in all or some versions; see Russell (1993, 1994) for discussion.

A stated goal of Optimality Theory is to attribute as much of grammar as possible to constraint evaluation, so it is not surprising that since this original formulation of OT a number of independent developments have tended to give more and more responsibilities formerly associated with other components, such as morphology and syntax, to this mechanism. For example, McCarthy & Prince (1993a, 1993b) have proposed that morphology proper introduces morphemes without specifying linear order, which is determined by the interaction of alignment and other constraints. Another proposal developed works including McCarthy & Prince (1993b:108-113), Mester (1994), Tranel (1994), Kager (1995), Dolbey (1996) and Orgun (1996), is that allomorph selection may be determined by constraints; under Tranel and Kager's version of this proposal, EVAL chooses the optimal candidate from a set derived simultaneously with different competing affixes. Taking this idea one step further, Fitzgerald (1995) has analyzed aspects of Tohono O'odham syntax, where the ordering and sometimes the presence of

grammatical particles is determined by a sentence's rhythm, by allowing Eval to consider multiple candidates for each sentence.

The proposals I want to make here are in a sense an extension of this trend. For this reason, and since it provides a simple example of why I think these proposals are necessary, a simple case of allomorph selection examined by Kager is a good place to begin. The example is a case of prosodically determined allomorphy in Djabugay (Patz 1991). This language marks vowel-final nouns for the genitive case by a suffix -/n/, and consonant-final ones with a suffix -/ŋun/, as seen in /guludu/, 'dove' + Genitive → /guludun/, and /gaɲal/, 'goanna' + Genitive → /gaɲalŋun/. This is clearly related to the fact that Djabugay does not tolerate CC codas, a constraint which adding -/n/ to /gaɲal/ would violate, but the language does not have any productive phonological process which can be claimed to derive one of these suffix forms from the other. Kager proposes to account for these facts by lexically listing both suffixes, and allowing EVAL to consider candidates for genitive nouns derived with both, subject to the phonological constraint *COMPLEXCODA and a lower ranked "morphological preference constraint", GENITIVE=/n/. This is illustrated in the tableaux below:

{gaɲal, [+Gen]}	*CC]$_\sigma$	PREF
a. gaɲaln	*!	
b. ⇒ gaɲalŋun		*

{guludu, [+Gen]}	*CC]$_\sigma$	PREF
a. ⇒ guludun		
b. guludu**ŋ**un		*!

I do not have any objection to this analysis, except that it only tells part of the story. What is missing is a formal connection from the *COMPLEXCODA constraint to the inventory of Genitive case ending allomorphs; assumedly it is not a coincidence that Djabugay disallows complex codas and has a backup ending compatible with this constraint in environments where -/n/ would not be. This consideration becomes even more clear in languages which have sets of parallel, or partially parallel, allomorphy. Two cases are considered in Estonian (by Kager) and Sami (Dolbey and Orgun), in both of which several inflections have competing suffixes with different shapes, selected according to which forms a better-formed metrical structure with the root. Another example can be found in Welsh, in which a number particles have allomorphs with and without final consonants, such as /ni/~/nid/ 'NEG', /a/~/ak/, 'and', /a/~/ag/, 'with' /si:/~/si:ð/, 'COPREL', and /ə/~/ər/~/r/, 'the'. Subject to other complications (see Awbery 1986, Ball & Müller 1992:93-97), the complete variants are used when the next word begins with a vowel, and the truncated forms elsewhere. Since only a small and unpredictable subset of Welsh particles show this alternation, it seems reasonable just to list these as allomorphs, and select them according to NOCODA and ONS. Welsh is otherwise tolerant of coda consonants, but following

McCarthy & Prince (1994) its appearance in this context can be viewed as Emergence of the Unmarked, in which a constraint otherwise completely dominated in a language comes into play in limited contexts. ONS motivates the use of unreduced allomorphs before vowels in order to supply the following syllable with an onset. But again, this treatment is descriptively adequate but not theoretically so, in that it fails to capture the parallel behavior of these particles, and fails to explain how NOCODA *motivates* this inventory of allomorphs.

I believe the answer to this problem is posit a redundancy relation between phonological constraints and lexical items. Under this view, following Bochner's terminology, allomorphs are less costly to learn if the differences between them help them conform to phonological constraints; or, from a more connectionist viewpoint, speakers' knowledge of specific lexical items overlaps with their knowledge of phonotactic constraints. (In this respect, redundancy can capture many of the same insights as phonological underspecification, a point which has been discussed by Stanley 1967 and Bochner 1993:16-20). In other words, speakers do not just use constraints to choose allomorphs, but understand that constraints are the motivation for the less-preferred allomorph's existence. Constraints still differ from metarules in that they are universal. Thus they do not actually need to be learned by the extraction of recurring patterns as rules are; they are imposed on the grammatical system from outside forces, the physics of articulation and airflow (see Hayes 1996, to appear) and the nature and perception of phonetic signals[11]. Subsequently, the process through which speakers connect them to individual representations will be different than in the case of rules and metarules: it will be top-down, rather than bottom up. But my claim is once the connections are made, they work largely the same.

In cases like the Welsh particles, there is still one more level of generalization which needs to be captured, that the formal relationship between full and reduced versions of each particle is more or less consistent. One can conceive of a language in which certain particles have consonant- and vowel-final allomorphs, determined in accordance with NOCODA, but where the vowel-final version was sometimes produced by deletion of a consonant, sometimes by adding another vowel, and sometimes by suppletion. Bringing the current proposal still closer to the LRM model, the generalization that alternating Welsh particles only use deletion can be captured by an (unproductive) morphophonemic redundancy rule XVC ↔ XV.

[11]Of course, phonotactic constraints might still in a sense be "learned" through the use of the vocal tract. Hayes (to appear) argues that constraints should be seen as the grammatical expression of external forces, distinct from those forces themselves.

Allow me to develop these ideas more explicitly by way of a slightly more intricate example. English requires syllable-final obstruent-obstruent clusters to agree in voicing, a constraint which I will designate SHARE LARYNX, in agreement with a (slightly more general) constraint proposed by Eulenberg (1996). When the plural suffix -/z/ is added to nouns ending in final voiceless obstruents, the resulting illegal cluster is regularly reconciled with SHARE LARYNX by devoicing the suffix, as in /'skifs/, /'downʌts/, and /'mʌnθs/; yet in a few irregular cases the voicing of a stem-final fricative assimilates to the suffix: /'hæf/-/'hævz/, /'nayf/-/'nayvz/, /'pæθ/-/'pæðz/, etc. Under traditional OT analyses, this can only be accounted for by allowing constraints to be ranked differently for different lexical items[12], a technique which has been applied in a few papers (Hammond 1995, 1996) but is not completely accepted.

Under the current proposal, however, we would posit the relational rules below:

Regular z-Plural Rule:
$X_{NSg} \leftrightarrow Xz_{NPl}$

Regular s-Plural Rule:
$XC_{NSg} \leftrightarrow XCs_{NPl}$ where C = [-sonorant, -voice]

Irregular z-Plural Rule:
$XC_{[+cont,-voi]NSg} \leftrightarrow XC_{[+cont,+voi]}z_{NPl}$

Pluralization Metarule:
$X_{NSg} \leftrightarrow XC_{NPl}$
|
[+cont, +sib, +cor, -ant]

The regular z- and s-Plural rules are fully autonomous, and selected according to the Elsewhere Condition. The Irregular z-Plural Rule has low autonomy, serving only to facilitate the storage of /'hævz/, /'nayvz/, etc. The Pluralization Metarule captures the fact that all three of these rules involve affixation of an alveolar sibilant. Finally, the SHARE LARYNX constraint,

Share Larynx Constraint:
$*C_{[-son,\alpha voi]}C_{[-son,-\alpha voi]})_{\sigma}$

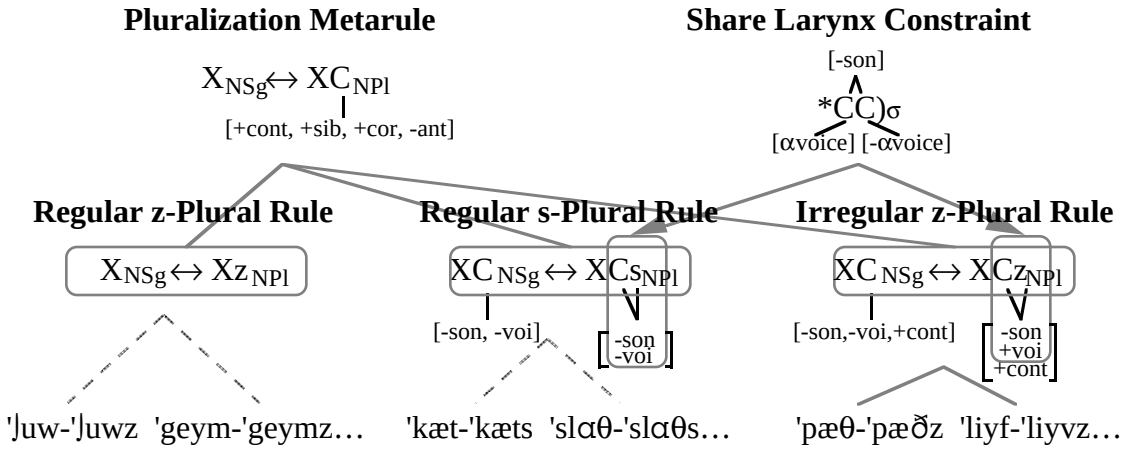
[12]For a consideration of what these constraints might be, see Cole & Kisseberth (1994) and Lombardi (1995).

serves as a kind of redundancy formalism capturing the fact that both the Regular s-Plural rule and the Irregular z-Plural rule create forms in which final obstruent clusters agree in voicing.

But note that, since the constraint is formulated prohibitively, we are necessarily talking of a slightly different sort of inheritance than in the case where a metarule applies as redundancy formalism over a set of rules or a rule over a set of forms. I will first assume that a constraint operates as a redundancy formalism over any portion of a representation which does not violate it. This point has already been made by Stanley (1967), and reiterated by Bochner (1993:16-20), who argue that interpreting constraints in this fashion allows fully-specified feature matrices to be stored at a cost determined only by their contrastive features. (Thus, for example, the lexical representation of an English word beginning with /n/ can include a specification that the consonant is [+voice], but since this is predictable from its sonority it can be learned free). What I want to add here is the notion that a constraint operates as a redundancy mechanism in any portion of a rule which "enforces" the constraint. This will be termed "inverse inheritance". Thus the cost of the regular s-Plural and irregular z-Plural Rules is lessened to the degree that they are motivated by Share Larynx.

This can be illustrated in the "property inheritance diagram" below.

Property Inheritance Diagram for English z- and s-Plurals:



This diagram introduces some new notational conventions:

The **vertical** dimension corresponds to degree of abstraction. Concrete word-forms are at the bottom, and successively more general representations are above them.

Lines between forms indicate property inheritance. That is, a representation which dominates other representations is one which captures redundant information in the dominated representations.

Arrows indicate motivation, or "inverse inheritance", from a constraint to a rule or representation; they indicate that the pointed-at portion of a rule is formulated so as to avoid the type of representation forbidden by the constraint.

Where the lower end of an inheritance line connects with a **box**, this box surrounds the portion of the dominated representation which is captured by the one above.

Solid inheritance lines mean that the dominating generalization has relatively low autonomy from the dominated one(s), representing overlapping storage.

Dashed inheritance lines indicate that the dominating generalization has relatively high autonomy from the dominated one(s); i.e., its use in the derived form(s) is more likely to represent a speech-time process than storage organization.

In the next section, this framework is applied to Maori.

6.2 A Solution to the Maori Problem

Maori verb alternations are an interesting problem because they are ambiguous. We want to make the two generalizations below, but under Generative models at least these are contradictory:

- "In the passive of gerundive form of some verbs, a consonant emerges which is not present in the basic form because Maori does not allow coda consonants."

- "Maori has several sets of suffixes for the passive and gerundive. The regular set is -/tia/ and -/taŋa/, but some verbs take -/hia/ and -/haŋa/, -/mia/ and -/maŋa/, -/a/ and -/ŋa/, etc., instead. If a verb is bimoraic, it is particularly likely to take -/a/ and -/ŋa/."

But I submit that these are only contradictory statements under one view of how morphology and phonology combine in word-form production, which I term the "modular-interactive" model. This model takes morphology and phonology to be discrete systems; it acknowledges that word-forms are produced by an interaction between the two domains, but insists that any one process must be completely a creature of one or the other. Under the Dual-Source Inheritance model, however, statements such as the two above are not contradictory.

Whereas the modular-interactive model claims that word-forms are shaped by both phonology and morphology, Dual-Source Inheritance claims that this interaction can occur at a higher level of abstraction, in that word-formation rules can derive from both as well.

To reach this level of abstraction, we need to extract one more level of phonological regularity from the Maori system. This can actually be done within the LRM framework as currently formulated. Recall (section 5.4) that a paradigm rule is equivalent to a transitive set of two-term relational rules, so that the formalism embodying the consonant/zero alternations in Maori, namely,

Consonant Paradigm Metarule:
$X_V \leftrightarrow XCia_{VPsv} \leftrightarrow XCaŋa_{VGer}$

can be broken down into the following components:

$X_V \leftrightarrow XCia_{VPsv}$

$X_V \leftrightarrow XCaŋa_{VGer}$

$XCia_{VPsv} \leftrightarrow XCaŋa_{VGer}$

The first two of these contain an obvious parallelism, the emergence of a consonant before a vowel. This can be distilled into the redundancy formalism below[13]:

Emergent Consonant Metarule:
$C \leftrightarrow Ø \; / \; \_\_)_\omega$

This rule resembles one which would be formulated in a Generative analysis, but as its bi-directional arrow indicates, it is meant to be interpreted differently; it describes a relationship, rather than a process. Its plain-text formulation is simply “a consonant which appears in one form will correspond to zero in another where it would have been final”. (Of course, this is one interpretation of structure changing rules within the Generative tradition itself; see Zwicky 1986 for discussion).

[13]At this point we might also consider formulating the rule as $Ø \leftrightarrow C \; / \; \_\_ \; V$. This formulation would actually work just as well in the discussion which follows. Within the context of Maori syllable structure, each formulation implies the other. I take up the issue of rule formalisms again in section 7.2.

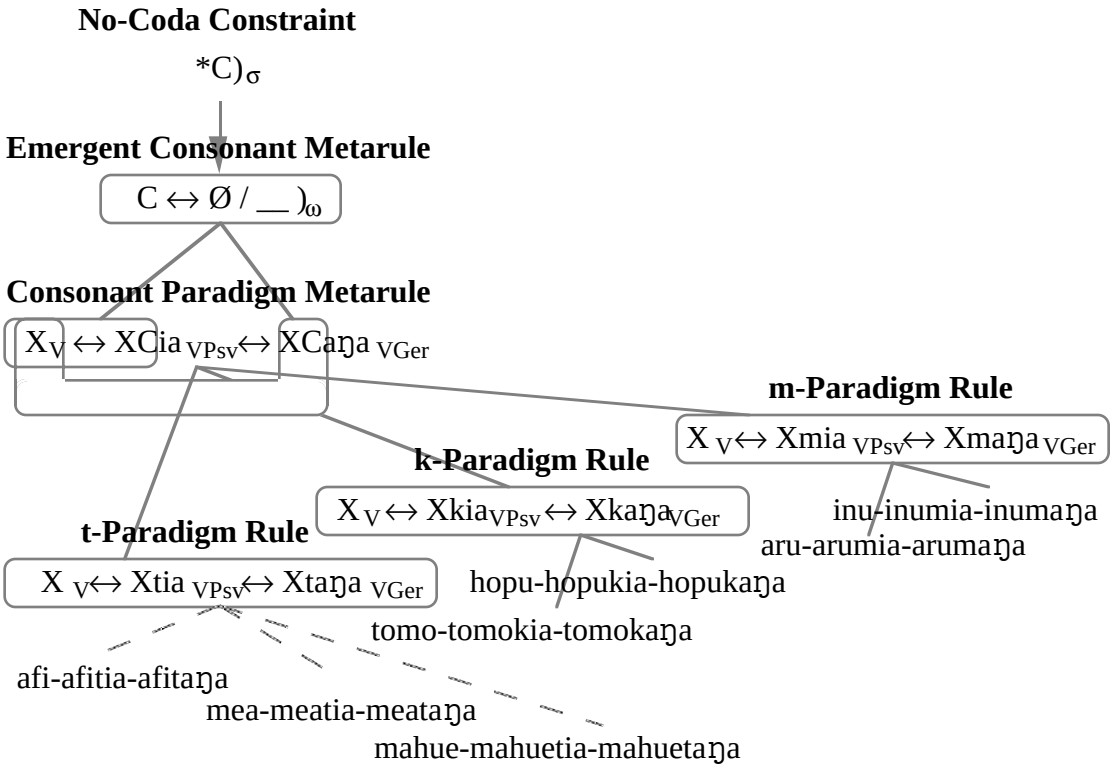
In parallel with our treatment of voicing alternations in the English plural discussed above, we can now describe this rule as motivated by a constraint, NO-CODA, which I formulate as follows:

No-Coda Constraint:
*C)$_{\sigma}$

Under the assumption that prosodic word boundaries are necessarily also syllable boundaries (which follows from Strict Layering; see Nespor & Vogel 1986), the emergent consonant metarule can be derived from this constraint by inverse inheritance; the omission of a consonant in what would be final position results in a form in conformance with it rather than one which violates it.

A small piece of this lexical network is illustrated below (note that the productivity of the t-Paradigm is reflected in the dashing of the lines from the paradigm rule to exemplar verbs, indicating that the rule probably applies in production rather than storage):

Property Inheritance Diagram for Maori Consonant Paradigms:



I posit that the proposed revision of LRM to include inheritance from both morphological and phonological redundancy formalisms, a.k.a. Dual-Source Inheritance, offers a more

descriptively and theoretically adequate account of consonant/zero alternations in Maori verb than has been formulable under earlier models.

The essential claims of this model, and their formal implementations, are reviewed below:

- Speakers make use of recurring patterns in the lexicon to render the process of learning a language's word-forms more efficient. Speakers may make use of these patterns to produce overlapping representations. Where a pattern is very regular, it can become "autonomous", and be used to predict word-forms at speech-time, obviating the need to store them.

- These patterns are represented as relational rules, describing relations between surface word-forms.

- Shared aspects of relational rules are captured by other, more general rules (metarules).

- A word can be partially described by a rule (or a rule by another rule) without being a perfect fit. The "cost", or of a word-form depends on the amount of independent information, i.e. information not captured by rules, needed to describe it.

- Where there are two rules such that one is a proper subset of the other, learning the use of the more general rule in contexts where the more specific is applicable incurs a greater cost than learning to use the more specific rule (the Elsewhere Condition). This cost corresponds to the productivity of the more specific rule.

- Constraints on phonological structures can also apply as redundancy formalisms to rules and representations (even though constraints are considered to be universally available, rather than learned). A constraint lessens the cost of learning any representation which conforms to it, and of learning aspects of rules which ensure that resulting forms conform to it (inverse inheritance).

To the degree that this approach has utility in a range of problems in other languages—either via the current formal implementation, or perhaps using different mechanisms to express the same ideas—it is a promising framework for future research in word-formation processes elsewhere.

7. Conclusions and Future Directions

The preceding section presents what I believe is a treatment of Maori consonant/zero alternations superior to what has been offered before, and a novel model of word-formation which may have application to other problems. In this concluding section a number of remaining language-specific and theoretical issues are addressed.

7.1 Further Issues in Maori Verbs

The current proposal describes one type of allomorphy in Maori, the appearance/disappearance of stem-associated consonants, fairly well. It links the alternations to their phonological motivation and simultaneously describes their place in the language's morphological system. However, we have also encountered several other types of allomorphy with varying degrees of regularity in Maori verb inflection. These are presently simply treated as mismatching; the paradigms affected are still linked to the overall pattern of verbal inflection in the language, but the respects in which these types of mismatching are regular are not expressed.

The first of these patterns is what was termed Elision in Generative accounts: the reduction of the expected -/ia/ and -/aŋa/ to -/a/ and -/ŋa/ in many but not all consonant-free verbs. To a certain extent, a treatment of these as simple mismatching is reasonable because of the extent to which we found that the process is irregular and variable. On the other hand, it is reasonable to ask how these might be addressed anyway, on the principle that whatever generalizations can be extracted from a grammar should be. In fact, for the general LRM approach to allomorphy adopted here, this particular pattern, and in fact any pattern where affix material is deleted, are problematic. Other examples can be found; in modern Greek, certain prefixes ending in vowels regularly omit them before bases beginning with vowels and glides (Philippaki-Warburton 1970:64-68). The LRM treatment of allomorphy—as recurring pieces of non-concatenative morphology applied in combination with affixation processes—cannot deal with such cases, because it has no way to describe regular relationships between competing rules (metarules capture what is shared across rules, but the differences are not explicitly represented).

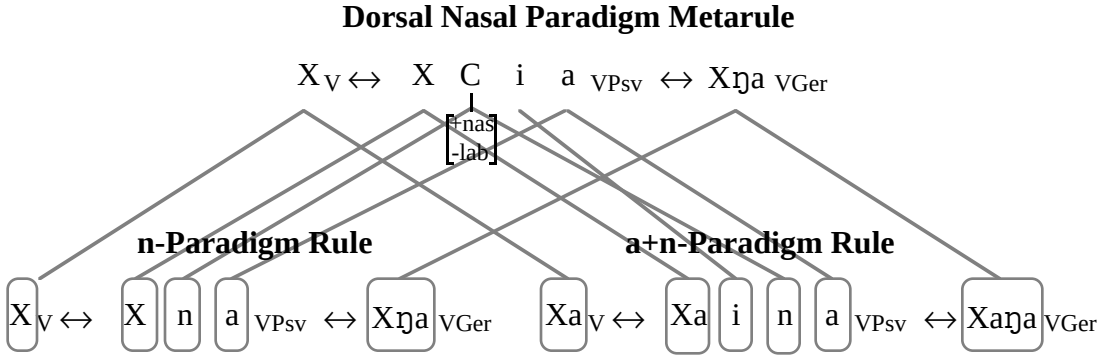
Such examples demonstrate a need to capture regularities from an exocentric, that is, affix-centered, as well as an endocentric or stem-centered point of view. By "affix-centered" I do not mean a return to the item-arrangement (Hockett 1954) view of affix morphemes as constituents, which LRM (along with item-and-process models such as Anderson 1992) eschews; only that a grammar must be able to capture formal regularities between words which share common morphological features but have different roots, as well as the inverse. This could

probably be implemented if we broadened our understanding of allomorphy metarules, so that they could capture redundant patterns between forms related along any morphological dimension. This may take a major retooling of LRM, beyond the scope of this paper. But whatever shape such a revised LRM might take, I think that the introduction of phonological constraints to the system proposed in this paper would be equally valid.

Other cases which it is less distressing to simply leave as mismatching are the loss of the Passive's usual /i/ in the n-Paradigm (where -/na/ is added to the base), and its misalignment in the a+n-Paradim (where we have forms like /uta/-/utaina/). Recall that we were unable to formulate an exact set of rules to describe these alternations (section 4.2). This is exactly the sort of case where mismatching is most appropriate: a specific pattern is clearly an example of a more general paradigm, but the details of its realization are quirky. The mismatching involved in the a+n-Gerundive is interesting in that it involves the linear order of elements, but not their substance.

We can represent these relationships as:

Property Inheritance Diagram for n-Paradigms:



Another major type of allomorphy not addressed yet is the phenomenon which has been termed Haplology in n- and ŋ-stems, where an expected -/naŋa/ or -/ŋaŋa/ comes out as just -/ŋa/. (Even though these sequences are tolerated morpheme-internally, and even in derived environments such as in /haŋaŋa/, gerundive of /haŋa/). We have captured this pattern, which occurs in four individual paradigms, in the Dorsal Nasal Paradigm Metarule (a submetarule of the Consonant Paradigm Metarule). I would argue that this metarule captures the pattern as well as the haplology rules of preceding Generative analyses. However, I think we can still do a little better job of explaining this phenomenon.

In section 4.4, I hypothesized that an OT account of Maori might attribute haplology to the OCP, but concluded that a constraint hierarchy which resulted in the deletion of a whole syllable, and applied only in the appropriate cases, would be prohibitively difficult to formulate. Under the Dual-Source inheritance model, something akin to this approach might be viable: we could formulate the OCP in such a way that sequences of the type -CaCa, where the C's are both dorsal (and maybe nasal) violated it, which could motivate the Dorsal Nasal Paradigm Metarule and ease its cost by inverse inheritance, paralleling the way in which I have proposed NO-CODA ultimately is responsible for consonant/zero alternations.

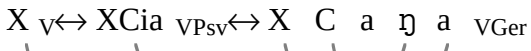
However, I think a better solution is possible. The explanation I want to propose for haplology is simply that the /ŋ/ of the -/ŋa/ added to these verbs is simultaneously a realization of the velar nasal usually associated with the gerundive *and* of the velar or alveolar nasal associated with the root.

Parallel cases are not hard to find in the morphological literature. For example, Yip (1995a) has argued that the -/z/ suffix of the English genitive plural (spelled s-apostraphe) is simultaneously a realization of the -/z/'s associated with the genitive and plural. Russell (1993, 1994) has proposed similar analyses of morphological coalescence phenomena in Nishga and Hua. Both Yip and Russell couch their analyses in variants of Optimality Theory in which affixation processes are treated as morphological constraints, and the same segment(s) can simultaneously satisfy more than one such constraint. In such frameworks it is actually the absence of coalescence which requires special effort. Within the lexical network school, similar assumptions are involved in Bybee's (1995:431) analysis (discussed earlier) that zero-derived English past tense forms like /'kwit/ and /'wed/ as examples of the -/d/ past tense schema implemented in a product-oriented manner, i.e. satisfied by the final /t/ or /d/ of the root. Similar phenomena also seem to be at work in German pluralization (see Köpcke 1988, 1993).

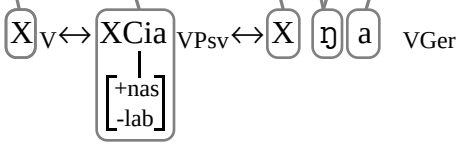
This approach can be formalized quite easily within the LRM model. Although there is no precedent I am aware of, there is no barrier to an analysis where one representation derives from another (i.e., the latter is a redundancy rule describing the former), and one element of the first corresponds to more than one element of the second. This involves mismatching, but the same kind of "misalignment" mismatching as in the analysis of the a+n Passive above. If such analyses are allowed, then the Dorsal Velar Paradigm Metarule can be derived from the general Consonant Paradigm Metarule as below:

Property Inheritance Diagram for Haplology:

Consonant Paradigm Metarule



Dorsal Nasal Paradigm Metarule:



This diagram is not entirely satisfactory since it is only indirectly evident, by a roundabout route, that the thematic consonant role of the Consonant Paradigm Metarule is necessarily a dorsal nasal here. This suggests that the formal notation of relational rules which I have used here may not be optimal. An examination of many cases might lead us to propose a new formalism for capturing patterns in lexical network models, but this will have to wait for future research[14].

One final set of Maori verb-forms to be tied in are the small number of "irregular" Passives such as /taakaa/-/taakaakina/, 'break' and /mea/-/meiŋa/, 'make', which do not fit into any of the major paradigm types. To the extent that they have features matching them, the cost of these can be partially alleviated by whichever paradigm rules they come closest to, and their unpredictable attributes can be described as mismatching.

7.2 Theoretical Comparisons and Other Issues

Formally, the Dual-Source Inheritance model proposed here is essentially an extension of Bochner's (1993) Lexical Relatedness Morphology model, emended to incorporate phonological constraints. It has taken this form because the LRM model is the currently the best-developed and most formally explicit example of the family of theories I have labeled Lexical Network models, which describe the type of morphological structures I am assuming as a background to

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[14]An interesting avenue to consider might be a rule formalism which explicitly represented the shared portions of the forms related by the rule in a literal fashion rather than through letter variables.

I believe that such an approach could obviate the choice noted earlier (note in section 6.2) between formulations of the Emergent Consonant Metarule. Rather than describing a relationship between forms, one of which has a consonant and one of which doesn't, the rule would describe a type of branching-point in the sequences of phonemes comprising morphologically related words.

the new theory. Other Lexical Network models might conceivably provide as good or better a platform for my claims, which are ultimately about how phonology enters into the formation of words.

A number of points can be made about this formal framework. I have already noted above that certain classes of alternations, exemplified by the elision of suffix vowels in Maori, are difficult to capture in it. It may also have other problematic limitations. For example, the word-based approach does not easily adapt to allomorphic phenomena effective across word boundaries. In Generative models it has been possible to view such cases as extensions of the phonological cycle from the word-internal to phrasal domain (c.f. Mohanan's 1986 treatment of syntax-sensitive sandhi in Malayalam, and my 1995 model of mutation in Welsh). This may be impossible in the LRM model as currently formulated, although if we adopt Hayes' (1990) proposal to account for such phenomena as word-internal processes, triggered by the assignment of morphological features from one word to another, this problem disappears.

The essential claims of the Dual-Source model are independent of these issues, however, so I will not dwell on them further here. More relevant are comparisons between the model of phonology/morphology interaction which has been proposed here and those which underlie other approaches to word-formation.

One of the main thrusts of the discussion throughout this paper has been the general inadequacy of what I have termed the modular-interactive approach to how morphological and phonological organization codetermine word-forms, which models the interplay of the two domains through the interleaving of morphological and phonological processes. This is essentially the position inherited from SPE, refined in Lexical Phonology (Kiparsky 1982, Mohanan 1986) and recently reworked into a non-derivational framework by Orgun (1994, Orgun (1996)). I have argued that this position is incapable of dealing with cases like Maori consonant/zero alternations in which an alternation is simultaneously phonologically motivated but partly morphologized. I have proposed that the solution to this problem is a framework in which phonological structure can be traced as the cause of an alternation, but not the *immediate* cause: phonological constraints motivate the shape of a general morphological pattern, through which individual rules and finally individual forms inherit the characteristics which reflect it.

This approach has superficial similarities to phonological theories which make use of repair rules, such as Paradis (1988a, 1988b), Myers (1991), Goldsmith (1993b), and Mohanan (1993), which claim that phonotactic constraints are implemented by rules triggered whenever such constraints are violated, in order to produce a non-violating output. The Dual-Source

Inheritance model shares with these approaches the assumption that constraint satisfaction is accomplished by rules, essentially a claim that avenues for satisfying constraints are explicitly represented as components of a language's grammar. This position is explicitly rejected by constraints-only models such as Optimality Theory, which view constraint-satisfaction strategies as epiphenomena of the relative ranking of phonotactic and correspondence constraints. In comparisons of OT and repair-rule theories, (c.f. Prince & Smolensky 1993:202-219) the ability of OT to reduce repair strategies to constraint rankings has been cited as an advantage, since clearly a theory with constraints and rules is less parsimonious than one with constraints alone. However, theoretical proposals may be evaluated in terms of their predictions as well as their inherent aesthetics. Although the notion is not taken up in repair-rule based theories to my knowledge, the possibility that constraint-motivated rules can be absorbed into a language's morphological system and function as redundancy rules over classes of related words rather than as speech-time processes—which I have argued is the case in Maori—is a strong argument that strategies for constraint satisfaction do exist as explicitly represented pieces of grammar. Thus, while such approaches do not really capture the same insights about allomorphy as the Dual-Source Inheritance model, they do represent an approach to more surfacy aspects of phonology which is compatible with it.

On the other hand, this does not necessarily mean that the Dual-Source Inheritance model is incompatible with the assumptions of Optimality Theory. A strong hypothesis is that the implementation of constraints via rules, embedded into morphology or otherwise, can replace devices of candidate generation, evaluation, and constraint ranking. For example, consider the schematic case where a violation of a phonotactic constraint C_1 is avoided by one strategy in general cases, but by another where it would result in a violation of a phonotactic constraint C_2. In a standard OT analysis, this is captured by grammars of the type,

C_1 » (Other constraints) » C_2 » (Still other constraints)

where the contents of "other constraints" and "still other constraints" determine the two strategies. In the Dual-Source Inheritance model, however, any such case could be captured as follows: the grammar will contain a rule describing a strategy for avoiding violations of C_1 (and C_1 will carry part of the weight for learning the rule via inverse inheritance), and a second rule describing a strategy for avoiding simultaneous violations of C_1 and C_2; since the type of structures which the second rule serves to avoid will be a subset of those avoided by the first, the Elsewhere Condition will have it take precedence (be less costly to learn) where applicable, depending on its regularity. Thus the constraints themselves need not be ranked. But whether constraint-ranking can be completely obviated in this way remains to be seen.

7.3 Metatheoretical Ruminations

My most basic objective in this paper was to provide a more descriptively and theoretically adequate account of consonant/zero alternations in Maori verbs than has been available within mainstream approaches to word-formation. I believe I have done this. A secondary objective was to explore a somewhat novel approach to word-formation. Whether or not my proposals are superior to existing alternatives across the board is an open question and one which it would be foolish to try to answer myself; however, I do believe that the types of problems I have been trying to address here—how exactly morphological and phonological generalizations combine in word-formation, and how individual words inherit formal properties from them—are ones which need to be examined more closely.

I have also had a third, "metatheoretical" objective here, of demonstrating a mode of synthesis for Formal or Generative approaches and Cognitive or Functionalist ones. I hope that in my efforts here, I have demonstrated that it is possible to construct linguistic theories which are both formally rigorous, and explicit in terms of the cognitive processes which they claim to be modeling. I do not believe that formal rigor by itself has much value if the primitives of a theory are not explicitly grounded outside of the formal system; a formally explicit but ungrounded theory fails the basic research objective of telling us what is going on when humans use language. On the other hand, cognitive theories of language function tend to become slippery if not explicitly formulated (or experimentally grounded in observable phenomena). The process of formalizing a theory forces us to be explicit about what it predicts will or will not occur, rendering it testable. Under this view, formalist and cognitivist approaches to language are not antagonistic but complementary.

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