6 Morphophonological Operations

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1 Introduction

This chapter describes the manipulations of the morphophonological shape of roots, stems and words which are found in morphological systems. It will be first and foremost a typological survey, but I will also argue for a particular view of the place of allomorphy in the grammar. I shall adopt the perspective that morphophonological operations of various sorts can be the exponents, or at least the partial exponents, of morphological properties.

   Chomsky's work in generative morphosyntax, despite undergoing radical changes of emphasis and philosophy, has retained two key related assumptions throughout its history, both of them derived from its structuralist antecedents. The first is that morphemes are listed lexical items, and the second is that they subtend syntax-like structural relationships within word forms (see Halle and Marantz 1993 for a recent defence of this). In other words, much work in generative grammar presupposes a concatenative, 'Item-and-Arrangement (IA)' approach (cf. Hockett 1958). On this conception, a morpheme is a thing, and morphology is simply the concatenation of these things, so is viewed as formally agglutinative. The plural *cat-s* of *cat* is then viewed as a kind of compound, but one in which there are highly restricted privileges of occurrence of the second 'lexeme', the plural morpheme *-s*. Cases of non-concatenativity, such as the alternation between singular *man* and plural *men*, are not treated as special types of deviation from this scheme, but are accommodated by appeal to greater abstraction in the forms of morphemes, and to morphological triggering of phonological operations. This position was inherited in generative phonology (*SPE*, Chomsky and Halle 1968). In more recent frameworks, we might, for instance, say that the plural morpheme was a floating palatal feature, which docked on to the /a/ of /man/ to give /men/ (see Wiese 1996 for a detailed analysis of the much more systematic case of German umlaut in these terms).

However, a distinct tradition, associated with Sapir (1921) in American linguistics, holds that morphology should be regarded as a set of processes acting on stems or words to produce new stems, words or word forms. In this 'Item-and-Process (IP)' framework (Hockett 1958), *men* is derived from *man* by a vowel-changing process, while *cats* is derived from *cat* by a process of attaching a formative or phoneme (sequence) -*s*. On this conception only the stems or words can be thought of as pairings of form and meaning. The morphological property of plural for the lexeme *man* is then realized as the difference in the two vowels. In effect, the property of plural is a paradigmatic relationship between forms, not a thing listed in the lexicon. Clearly, both perspectives have little difficulty in providing an adequate description of *cats*. The differences revolve around the extent to which we regard examples like *men* as indicative of an important type of morphological operation or just a more abstract instance of concatenation.

One consequence of an IP view is that we do not have to picture affixes as lexical entries, because they do not have to be listed form–meaning correspondences. Rather, affixation can be thought of as the result of an operation, such as Aronoff's (1976) Word Formation Rules for derivation or Hoeksema's (1985) head operations (see Beard, Derivation). A radical version of this view is Beard's Separation Hypothesis (ibid.), some form of which is widely assumed in inflectional morphology (see Stump, Inflection). However, this does not, of course, prevent us from assuming that the concrete formatives themselves (such as the -*s* affix of *cats*) can have their own phonological properties. The question that is raised by the IP perspective is simply this: are there operations over phonological form, or equivalently, alternations in phonological form, which can be regarded as the exponent, or at least the partial exponent, of a morphological property? In a strict Item-and-Arrangement model the answer would be 'no', and all phonological variation would be ascribed to perhaps rather abstract underlying phonological properties of the affixes and stems. On an IP perspective we can answer the question positively, thus giving substance to the notion of 'morphologized phonology'.

In many instances, no doubt, a good case might be made for treating a superficially processual phenomenon as underlyingly the result of concatenation of things in tandem with the application of purely (or perhaps 'essentially') phonological processes and phonologically defined constraints. Infixation in languages such as Tagalog is arguably of this type (see section 2.2). Indeed, Stonham (1994) argues in detail that all of the most processual phenomena discussed in the literature are susceptible to such analyses. He, in common with many phonologists, views this as an advantage, in that it means that there is only one morphological operation, that of concatenation. This is then supposed to lead to a more constrained theory (of morphology, presumably), on the assumption that all the phonological operations are independently motivated phenomena of Universal Grammar.

To see what is at stake, consider a case of morphologically triggered allomorphy in English, the famous case of Velar Softening. In *SPE* a rule system

was proposed for capturing the lexical relatedness of pairs such as *critic ~ criticize, analog ~ analogy*. The /k ~ s/ and /g ~ dʒ/ alternations were the result of a palatalization rule triggered by a high front vowel. This meant that the suffix *-ize* had to be furnished with an underlying vowel /I/ (a tense /i/) which later underwent a battery of changes, the Great Vowel Shift, to become /aɪ/. The palatalization process itself had to be split into several subprocesses, because /s/ is not what one would expect phonetically from adding a palatal element to /k/. The upshot is that the relatedness can be expressed in the vocabulary of phonology, and all the roots and affixes can be given a single underlying form. In an IP model it is open to us to argue that the consonant alternations are triggered purely by the morphological affixation process, and serve to partially identify that process. This can be coded as a process which replaces /k/ with /s/ in tandem with affixation, or as a set of relations between listed stem allomorphs, with the affix marked to select the 'softened' allomorph. The crucial point is that there is an explicit recognition that Velar Softening is a *part of* the affixation process, and not just an accidental by-product of it.

Now, the *SPE* analysis of Velar Softening is a modified recapitulation, of course, of a set of historical changes (in English and Norman-French). As is typical in such analyses, the cost is a battery of rules, extrinsically ordered, operating over underlying forms which are often strikingly distant from the surface forms. Even with the more recent technology of autosegmental multi-tiered representations and phonological operations triggered by constraints, a detailed analysis of a single language within this framework of assumptions retains essentially all the properties of the original *SPE* model. A good example of this is Rubach's (1993) meticulous description of Slovak (though unfortunately, the point is not so obvious, because detailed studies such as Rubach's, while indispensable for testing phonological models, are rather rare).

Among many morphologists and a good many phonologists, the assumption remains that a common underlier must be assumed for all alternants and that phonological determinants must be factored out at all costs. However, for present purposes, there are several reasons for retaining a perspective closer to IP. In subsequent discussion I shall refer to the phonological alternations which realize morphology as 'operations'. However, it is not crucial to the thesis that the alternations in phonological form be coded in the grammar as explicit operations, as opposed to, say, redundancy rules relating allomorph types. The crucial point is that there should be cases in which morphology is not realized affixally, where the phonological form of stem is the principal exponent of some morphological property. Under this conception the use of a particular prosodic template as the exponent of a given category would count as a non-affixal realization (see Aronoff 1994: ch. 5 for a detailed discussion of such cases). There are several reasons for adopting such a perspective here.

First, it will be convenient to view morphological exponence in terms of the operations 'visible' at the surface for purely expositional reasons, in order to bring out the rich variety of formal relationships which morphology can

commandeer for its semiotic and grammatical purposes. This can be of practical value to the descriptive linguist working on little-known languages, for whom highly abstract investigation might be premature.

Second, the phonologically driven approach treats as a surface accident any correspondence between allomorph selection and morphological function. This means that allomorphy can never be viewed as a (partial) exponent of a morphological property. Typologically, then, we would be saying that languages are permitted to list floating features as morphemes (which may, of course, be true), but we would not be allowed to say that languages are permitted to signal a difference in morphological property by means of a paradigmatic relationship between singular and plural allomorphs. Now, it is quite possible that nothing of interest will come of the IP research programme which asks such questions, so it is feasible that the 'phonology first' strategy will ultimately prove correct. However, suppose that the IP view is, after all, correct. By ruling out that possibility from the outset, we will never discover the error of our ways. The IP programme would not, however, impinge on phonological research, to the extent that the devices which phonologists appeal to are really phonological, so there could be no corresponding methodological catastrophe awaiting phonology. Thus, from a purely methodological standpoint, it is better to make the richer set of assumptions embodied in the IP view.

In a related vein, there is a strong methodological reason for rejecting the phonology-first approach and adopting an IP perspective, based on considerations of learnability. Item-and-Arrangement theorists (often tacitly) assume that restricting all morphological operations to simple concatenation makes grammatical theory more constrained. This is then supposed to have beneficial consequences for the child acquiring language. Actually, as far as I can tell, such talk is almost invariably empty. This is because learnability considerations have to be computed over the whole of the relevant portions of the grammatical system. In order for considerations of 'restrictiveness' to have any meaning at all, what has to be shown is one of two things: either that the formal class of languages permitted under one conception leads to learnability problems, and that these are absent under the other conception, or that the best available theory of language learning is compatible with one conception and not the other.

Needless to say, no one has even attempted to make a case of either sort. Worse than this, no one has ever demonstrated that learnability considerations based on 'restrictiveness' are even relevant to morphology. The point here is that in syntax a case can be made for the existence of highly abstract universals on the basis of the 'poverty of the stimulus' argument (cf. Chomsky 1980). This argument gains much of its strength from the observation that syntax is an unbounded system, and, at a more practical level, that language users show evidence of linguistic knowledge which is underdetermined by the primary data. Now, although morphological systems can be very large and can occasionally show recursion, it is far from clear that they pose any 'poverty of the stimulus' problems. On the contrary, a characteristic of morphological systems

is that they are subject to idiosyncratic restrictions, indicating that storage, rather than generation, is the key device. But this would suggest that there are no learnability-theoretic reasons for wishing to impose some notion of restrictiveness. On the other hand, at a more practical level, learnability considerations are, indeed, relevant where analyses require highly abstract underlying forms and complex interactions. This is because in many cases the 'correct' analysis can be obtained only from a fairly detailed survey of the entire system, with some crucial examples appearing only in vocabulary which is normally learnt fairly late in acquisition. Now, when the language learner has yet to be exposed to all the relevant data, s/he will presumably have to construct a grammar which is ultimately inadequate and will have to be overhauled. The simplest strategy is memorization of allomorphic variants, and given that we are dealing with lexemes or finite lists of affixes, this strategy will presumably be successful. Moreover, for the language use system (perception and production) storage of small sets of alternations is not likely to be disadvantageous compared to on-line production. Thus, it is difficult to see why any language learner should bother to project the more abstract, phonologically driven analyses.

An objection to this strategy is to say that it leaves unconstrained the space of possible operations that can be posited. This may be true, but then it is unclear why we should need to constrain that space. Children can learn language games which involve reversing the order of phonemes or syllables of a word. However, no natural language described hitherto has been shown to employ this strategy for grammatical purposes. But this does not mean that such a possibility is excluded by Universal Grammar; rather, it means that the chances of a language developing such a strategy, given the way that language change occurs, are minutely small (though theoretically possible, say, as a development from an adolescent language game). It may also mean that the learning strategies adopted by small children would deter them from positing such a rule. Finally, within the perspective of Optimality Theory, Universal Grammar must countenance a completely arbitrary set of operations over strings (the Gen function of McCarthy and Prince 1993a: 86). The effects of these operations are filtered out by ranked constraints, but in principle the theory permits a very wide spectrum of operation types to surface.

The rest of the chapter surveys the most common processual phenomena that can be seen as helping to realize a morphological property.

2 Concatenation

As we have seen, even the concatenation of concrete forms is often associated with morphophonological operations which serve as partial morphological exponents. This is true both of compounding and of affixation.

2.1 Compounding

Compounding is canonically characterized as the concatenation of two words to form another word. This is arguably the simplest type of morphology, and one from which many types of affixation derive historically. In practice, it can be extremely difficult to distinguish this from syntactic phrase formation. However, when compounded types become fossilized, the head of the compound may turn into an affix. At intermediate stages it might be very difficult to decide which type it falls into. This is also a problem in languages in which (bound) roots are compounded, for we are not then dealing with the formation of a word from other words. Neoclassical compounding in English poses such problems: is the *hypo-* of *hyponym* a prefix or a bound root compounded with another bound root (notice the stress shift in *hyponymy*, something more characteristic of affixes than compounded elements in English)? The type of compounding seen in incorporating languages (e.g. Chukchee; see Muravyova, Chukchee (Paleo-Siberian)) is also frequently a type of root compounding, in which a new stem, rather than a new word, is formed.

On the periphery of genuine word formation and word creation are so-called stub compounds in Russian and a number of other languages. Here, we concatenate some phonological subpart of each compounded element (in Russian this is generally a bimoraic syllable, which effectively means a closed syllable). Some examples are shown in (1) (I have separated the elements by = for ease of reading):

(1) (a)   zarabotnaja plata   zar=plata
          'earned payment'   'salary'

     (b)   kollektivnoe xozjajstvo   kol=xoz
          'collective farm'   'collective farm'

     (c)   Gos=sort=sem=fond
          Gossudarstvennyj Fond Sortovyx Semjon
          state collection specialist.GEN.PL seed.GEN.PL
          'State Specialist Seeds Collection'

     (d)   NIIN=Avto=selʲxoz=maʃ
          Nautʃno-Issledovatelʲskij Institut Informacii po Avtotraktornomu
          scientific-research institute of-information on tractor
          i Selʲskoxozjajstvennomu Maʃinostroeniju
          and farming machine-construction
          'Research and Information Institute for Tractor and Farm Machinery Construction'

In (1d) we see an abbreviation incorporated into the compound, which allies the construction with non-morphological (non-linguistic?) means of word creation such as acronyms. In addition, the component *selʲxoz* is constructed from

the compound adjective *sel^j-sk-o-xozjaj-stv-ennyj*, *village-ADJ-o-husbandry-NOM-ADJ* (where *-o-* is a meaningless intermorph) by taking the CVC initial of the two lexical elements, *sel^jskij* 'pertaining to the village' and *xozjajstvennyj* 'pertaining to husbandry'. Note, too, that this compound is effectively headless, because the element that would correspond to a head, *institut* 'institute', is incorporated into the abbreviated first component *NIIN-*. In (1c), on the other hand, we observe that the element order of the compound is different from that of the full name, in that it seems that the compound is headed by its semantic head, *fond* 'collection', and its modifiers precede it. This is interesting, because genuine pre-head modification in root compounds is very rare in Russian (indeed, genuine root compounding is limited).

2.2 Affixation

The most important affixal operations are prefixation and suffixation.[1] These operations may be combined to conjointly realize a single process by means of a circumfix. Prefixation and suffixation do not invariably entail that the prefix/suffix appears on the far left/right of the word or stem, however. Prosodic considerations may demand that the affix appears inside the stem to which it is attached, in which case we have an infix. This is discussed in detail by McCarthy and Prince, Prosodic Morphology.

An intriguing puzzle is presented by circumfixation, in which a given morphological property is signalled by a simultaneous prefixation and suffixation process. In most cases both prefix and suffix are independently attested, usually with rather different meanings or functions. This is true of the two types of Comitative case in Chukchee (Muravyova, Chukchee (Paleo-Siberian)). However, the negative form of the verb in Chukchee is formed by a circumfix *e- . . . -ke*, neither part of which occurs elsewhere except in the privative circumfix added to nouns *e- . . . -ki*. The latter is almost identical to the negative circumfix, and is presumably closely related to it.

The term 'infixation' is properly applied to the insertion of an affix within some other morpheme (and not, for instance, simply between two other morphemes). Thus, we might wish to say that the plural form *mothers-in-law* is derived from the singular *mother-in-law* by inserting the plural formative *-s* between *mother* and *in*, but this would not count as infixation (for discussion of such cases see Stump 1995b). Genuine examples are provided by the Tagalog examples (taken from McCarthy and Prince 1993a: 101, in which an affix *um-* creates verb forms). When the verb stem is vowel-initial, *um-* appears as a prefix. When the stem begins with a consonant (or consonants), *um-* shifts to the right of the onset of the first syllable:

(2) aral   um-aral   'teach'
     sulat   s-um-ulat   'write'   *um-sulat
     gradwet   gr-um-adwet 'graduate'   *um-gradwet

In other words, the prefix is aligned as far to the left as possible, provided it doesn't create a coda.

Particularly interesting cases from Ulwa are shown in (3) (McCarthy and Prince 1993a: 109–10; *idem*, Prosodic Morphology):

(3) bás   'hair'   bás-ka   'his hair'
      ásna   'clothes'   ás-ka-na   'his clothes'
      arákbus   'gun'   arák-ka-bus 'his gun'

Here the suffix *-ka* is placed immediately after the stressed syllable; that is, it is aligned to the right of the stress foot of the stem. The interaction between morphological positioning of the affix and phonological constraints has been extensively explored with Optimality Theory, and the reader is referred to McCarthy and Prince 1993a, 1995b and Prosodic Morphology).

Reduplication is a morphological operation which, since Marantz 1982 has been fruitfully analysed as a species of affixation of a prosodic template to a stem, followed by copying of that stem and association to the template. More recent conceptions are discussed in McCarthy and Prince (1995b and Prosodic Morphology). The simplest type is simple copying of an entire root, as in the Japanese examples (4) and (5) (from Tsujimura 1996: 152, 107). In (4) we see examples of mimetics (similar to onomatopoeic words):

(4) pota-pota   'dripping'
      hena-hena   'weak'
      pitya-pitya   'splashing'

In (5) we see cases of Renyookei reduplication, which creates a particular verb stem in conjugation:

(5) nak-   'cry'   nakinaki
      tabe-   'eat'   tabetabe
      yorokob-   'rejoice'   yorokobiyorokobi

In more complex cases reduplication is only partial. Tagalog, for instance, has (in addition to whole form reduplications) reduplications of the sort shown in (6):

(6) (a)   sulat   'writing'   su-sulat   'will write'
            trabaho   'working'   ta-trabaho   'will work'

      (b)   magpa-sulat causative   magpa-pa-sulat 'will cause to write'

      (c)   basa   'reading'
            mambasa   infinitive mam-ba-basa   nominalization

Notice that the reduplication can affect a root which has already been prefixed (6b), and may even appear to affect part of the prefix itself (6c).

In other cases, part of the reduplicated affix is pre-specified. This was true in Ancient Greek, for instance, where the first consonant is reduplicated in the prefect prefix, but the vowel is always /e/ (cf. Spencer 1991: 150):

(7) ly:o: 'I release'   le-lyka   'I have released'
     grapho: 'I write'   ge-grapha   'I have written'

Finally, we sometimes find that the reduplicated portion is introduced within the morpheme (i.e. as an infix). A simple example is Samoan, in which certain verb forms are the result of reduplicating the first syllable of the main stress foot of the word (which effectively means reduplicating the penultimate, stressed syllable; cf. ibid. 151):

(8) alofa   'love (sg.)'   a-lo-lofa (pl.)

Cliticized elements may be reanalysed over time as affixes, and this is probably the commonest source of inflectional affixes. Zwicky and Pullum (1983a) have argued that this has happened to the English negation formative *-n't* (as in *hasn't*), and that this is now an inflection. The transition can be seen in midstream in the reflexive clitic/affixes of some Scandinavian languages and of Russian. In (9) we see examples of the Russian reflexive formative *-sja/s^j* with various verb forms:

(9) myt^j 'to wash'   myt^j-sja   'to wash oneself'
     moju   'I wash'   moju-s^j 'I wash myself'
     mojem   'we wash'   mojem-sja   'we wash ourselves'
     myl   '(he) washed' myl-sja   'he washed himself'
     myla   '(she) washed' myla-s^j 'she washed herself'
     mojuʃtʃij   '(one who is) mojuʃtʃiesja   '(ones who are) washing
                 washing'   themselves'

The reflexive formative *-sja/s^j* is always the rightmost element. In general, we find the *-sja* allomorph after consonants and *-s^j* after vowels; but this is not true of the present participles, where we find *-sja* even after a vowel (*mojuʃtʃiesja*). Such phonologically unmotivated deviation is typical of an affix. In addition, the reflexive formative is regularly used to form a passive voice form from imperfective verbs. This suggests that we are dealing with an inflectional suffix (though it is typologically unusual for passive morphology to be outside agreement morphology).

On the other hand, the *-sja* formative is often simply a part of the lexeme without any identifiable meaning of its own, and certainly without any inflectional function, as in *uʧit^j-sja* 'to learn' (cf. *uʧit^j* 'to teach') or *loʒit^j-sja* 'to lie down' (imperfective) (cf. *leʧ^j*, which is the perfective form of the same lexeme, without any 'reflexive' morphology). In *loʒit^{j}sja* the tense and agreement markers occur inside the *-sja* formative, just as in the case of a genuine reflexive:

(10) loʒ-u-sʲ   loʒi-l-a-sʲ
      lie-1sg.PRES-SJA *lie-PAST-FEM.SG-SJA*
      'I lie down'   'she lay down'

The problem here is that we must say we have a case of 'internal' inflection if we regard the *-sja* as part of the lexeme itself. Moreover, this internal inflection is identical to the external inflection we get from an ordinary verb. The situation is readily understandable if we think of the *-sja* formative as a clitic. It is noteworthy that in most other Slav languages the cognate formative is still very clearly a clitic. Thus, by some criteria *-sja* is a suffix, and by others a clitic.[2]

3 Morphophonemic processes (often accompanying affixation)

3.1 Apophony

The most well known cases of apophony (ablaut) serving as a morphological exponent come from the Semitic languages, though it is also found in other Afroasiatic languages, including Cushitic (cf. Hayward, QAFAR (EAST CUSHITIC)). Haiman (HUA (PAPUAN)) describes a particularly interesting case in the Papuan language Hua. Thus, the basic (default) shape of a perfective active verb stem in Modern Standard Arabic is CaCaC – for example, *katab-a* 'he wrote'. Verbs of this class form their passive by replacing the vocalism with *u-i*: *kutib-a* 'it was written'. Many nouns in Arabic, including recent borrowings, have a 'broken plural', in which both the vocalism and the disposition of vowels with respect to consonants may be altered. Thus, one class of nouns behaves like the word *film* 'film', which has the plural *aflaam* (see McCarthy and Prince 1990a for detailed discussion). These systems have been discussed in great detail in the wake of the work of McCarthy (1979), who provided an IA analysis within an autosegmental framework. Within the framework of Prosodic Morphology a more processually oriented account has been proposed by McCarthy and Prince (e.g. PROSODIC MORPHOLOGY).

Semitic provides abundant cases in which the consonantism of a stem is manipulated for morphological purposes, though this is widespread in certain Penutian languages of California (e.g. Yokuts, Miwok; cf. Archangeli 1983, N. Smith 1985). Though not traditionally referred to as apophony, this is a comparable type of operation. See below on consonant gemination in Amharic. McCarthy and Prince (PROSODIC MORPHOLOGY) provide more extensive discussion.

A relatively common type of apophony involves a nasal prosody. In (11) we see examples from Terena (Spencer 1991: 157), in which the nasalization is the exponence of 1sg:

(11) (a) emoʔu 'his word' emõʔu 'my word'
      (b) owoku 'his house' õwõⁿgu
      (c) piho 'he went' ᵐbiho 'I went'

In (11a) the nasalization affects all the sonorants in the word (skipping the glottal stop). In (11b, c) we see that the nasalization moves from left to right until the first plosive, giving a prenasalized stop.

3.2 C-mutation

It is very frequently the case that affixes induce phonological changes in the final consonant (or consonants) of their bases and that these alternations then become morphologized. At this stage we can say that the alternations cease to be part of the productive phonological system, but remain as signals of the affixation operation and hence as partial exponents of the morphological process.

When consonantal alternations take place word-initially, we speak of (initial) consonant mutation, which we could also call left-edge mutation. This is described fully for the Celtic languages in Fife and King (CELTIC (INDO-EUROPEAN)), and is also well known from the West African language Fula and its relatives, and from the Siberian language isolate Nivkh. Such mutation often arises historically from the effects of prefixes which induce phonological alternations but which are then lost. Initial consonant mutation has been analysed in terms of the effects of a floating autosegment (cf. Lieber 1987), mirroring diachronic change to some extent, though the alternations are sometimes such as to require phonetically unmotivated derivations. Keenan and Polinsky (MALAGASY (AUSTRONESIAN)) discuss a similar kind of left mutation which is triggered by certain types of compounding process in Malagasy, somewhat reminiscent of the mutation found in certain types of Welsh compound. In these cases there is no synchronic purely phonological source for the consonant alternations.

Typologically speaking, we could easily use the term 'mutation' to refer to non-automatic consonant alternations occurring when the affix is still overtly present. Similarly, (and more commonly) we could speak of right-edge mutation when a suffix induces a morphologized change. Slavic palatalizing suffixes provide a rich source of examples of such right-edge mutations (cf. Rubach 1984 on Polish, Rubach 1993 on Slovak). Note that many phonologists within structuralist as well as generative paradigms propose quasi-phonological treatments of such phenomena, which generally require rather abstract derivational analyses appealing to various types of rule-ordering convention.

A rather intriguing case of right-edge mutation without synchronic suffixation is found in the West Nilotic Kenyan language DhoLuo. Nouns form their singular construct forms (used for expressing possession) by mutation, which in some cases has the effects of a feature-switching operation, in that a basic

voiced sound may become voiceless, while a basic voiceless sound may be voiced (Stafford 1967) (these examples also show Advanced Tongue Root vowel alternations):

(12)   Singular   Singular construct   Meaning

   gɔt   god   'hill'
   lʊθ   luð   'stick'
   kɪdo   kit   'appearance'
   lwɛdo   luet   'hand'
   puoðo   puoθ   'garden'
   ʧogo   ʧok   'bone'
   buk   bug   'book'
   kɪtabu   kɪtap   'book'
   gowi   gop   'debt'
   barua   barup   'letter'
   sɪgana   sɪgand   'story'
   bul   bund   'drum'
   lwɛɲ   lueɳʤ   'war'
   ʧɔŋ   ʧoŋg   'knee'
   ʧiemo   ʧiemb   'food'
   ndara   ndaʧ   'road'
   taya   taʧ   'lamp'
   wɪʧ   wi   'head'
   agulu   aguʧ   'pot'

A similar alternation is found with accompanying suffixation in the plural and plural construct forms. This feature switching is sometimes cited as an instance of an exchange rule, and has been cited as the kind of phenomenon which poses difficulties for purely concatenative morphology (e.g. Anderson 1992: 43). Stonham (1994) points out that several cases (including DhoLuo) involve singular/plural alternations, and suggests that in some words it is the plural stem which is basic. However, this doesn't explain other cases; nor does it help to explain why in DhoLuo the (singular) construct form also participates in the alternation.

Consonants between vowels often undergo lenition (or less commonly, fortition) processes, depending on prosodic, especially syllabic, structure. Since syllable structure is often affected by affixation, such alternations can easily become morphologized. Such word-medial alternations are generally referred to as (consonant) gradation. A well-known instance of this occurs in Finnish (Karlsson 1987: 30f), where long consonants in open syllables alternate with short consonants in closed syllables (length is shown as a doubling of the letter in the orthography; I have used a hyphen in these examples to separate a suffix from its stem):

(13) (a) kaappi 'cupboard'   kaapi-ssa 'in the cupboard'
     (b) matto   'mat'   mato-lla   'on the mat'
     (c) kukka   'flower'   kuka-n   'of the flower'

This is morphologized, as shown by three facts. The alternation is not entirely regular phonologically. First, the alternants of original short vowels undergo gradation which cannot be captured as a natural phonological process:

(14) (a) tupa   'hut'   tuva-ssa   'in the hut'
     (b) katu   'street'   kadu-lla   'on the street'
     (c) jalka   'foot'   jala-n   'of the foot'
     (d) kenkä   'shoe'   kengä-n   'of the shoe' [=keŋŋän]
     (e) polke- 'trample'   polje-n   'I trample'
     (f) särke- 'break'   särje-n   'I break'
     (g) puku   'dress'   puvu-n   'of the dress'

Secondly, the phonological context of being in a closed syllable is not suffi-cient to determine when gradation will take place. Some suffixes do not trigger the process. Thus possessive suffixes, even if they close the syllable, never trigger gradation:

(15) katto 'roof'   kato-lle   'on to the roof'
                      katto-mme   'my roof'   [*kato-mme]

Thirdly, gradation does not take place before a long vowel:

(16) renkaa- 'ring'   renkaa-n 'of a ring' [*rengaa-n]

However, it does generally take place before a diphthong: for instance, one formed by the plural suffix *-i*:

(17) kato-lle 'on to the roof'   kato-i-lle 'on to the roofs'

But if the stem ends in a long vowel underlyingly, as in the case of *renkaa-* in (16), then gradation is still blocked, even though vowel length in diphthongs is neutralized:

(18) renkaa- 'ring'   renka-i-lta 'from the rings' [*renga-i-lta]

3.3 Tone

Innumerable languages make use of tonal alternations as exponents of gram-matical categories. A straightforward example is again provided by DhoLuo. In (19) we see the imperfective and perfective forms of the phrase 'taste soup':

(19)		Imperfective	Perfective
	1sg.	á ! bíló kàdò	à bílò kàdò
	2sg.	í ! bíló kàdò	ì bílò kàdò
	3sg.	ó ! bíló kàdò	ò bílò kàdò
	1pl.	wá ! bíló kàdò	wà bílò kàdò
	2pl.	ú ! bíló kàdò	ù bílò kàdò
	3pl.	gí ! bíló kàdò	gì bílò kàdò

(The raised exclamation mark (!) indicates downstep, an acute accent means high tone, and a grave accent means low tone.)

3.4 Stress

Although stress, like tone, is an extremely common phonological feature used for distinguishing lexemes, it is not, perhaps, used morphologically as much as tone is. However, it isn't difficult to find examples of languages in which derivational or inflectional forms are distinguished solely by stress, and stress is regularly an important concomitant of affixation and compounding. An often cited case of stress apparently being used for derivation is that of English *contrást* (verb) versus *cóntrast* (noun), and there are a fair number of similar examples. However, it is probably better to relate this to a general difference between the stress patterns of nouns and verbs: nouns exhibit what is often called Noun Extrametricality, under which the final syllable is ignored for stress purposes. Verbs do not show this property. Hence, given some principle placing stress on the final syllable of verbs with Latinate prefixes such as contrast, we would in any case expect the stress to shift back by one syllable after the verb had undergone conversion to a noun. Interestingly, no such stress alternation is shown when a verb arises by conversion from a noun. Thus, the verb (and adjective) *abstráct* has end stress, and the noun *ábstract* has initial stress; but the verb derived from the noun *abstract* meaning 'to write an abstract of an article' (i.e. produce an abstract of) has the same stress as the noun: *ábstract* (cf. Kiparsky 1982a).

   Stress is often used to mark membership of particular cells of inflectional paradigms, and many authors speak about 'paradigmatic stress' in this context. Thus, in Spanish the first- and third-person singular forms of the preterite of verbs are given end stress, in violation of the usual pattern for vowel-final words, which is to have penultimate stress. This can give rise to minimal pairs as in *háblo* 'I speak' (1sg. pres.) versus *habló* 'he spoke' (3sg. preterite).

   Phonologists regularly analyse such cases in terms of stress assignment rules or principles triggered by various morphosyntactic features. However, some alternations are not necessarily easy to analyse in such a quasi-phonological fashion. One such example comes from Russian. The overwhelming majority of monosyllabic, neuter noun stems in *-o/-e* exhibit a curious stress exchange in

the singular and plural paradigms. In one class the singular is ending-stressed throughout and the plural stem-stressed, while in the other class it is the plural that is ending-stressed and the singular which has stress on the stem. In (20) we see two such nouns, *okno* 'window' and *mesto* 'place', inflected for all their cases:

(20)	Case	Singular	Plural	Singular	Plural
	nominative	oknó	ókna	mésto	mestá
	accusative	oknó	ókna	mésto	mestá
	genitive	okná	ókon	mésta	mest
	dative	okné	óknam	méste	mestám
	instrumental	oknó	óknami	méstom	mestámi
	locative	okné	óknax	méste	mestáx

This could be taken as another instance of an 'exchange rule' (cf. discussion of DhoLuo mutation above).[3]

3.5 Vowel length

In Slovak the genitive plural of (mainly feminine) nouns in the *-a* class and the (neuter) *-o* class has no suffix, but usually has a lengthened final syllable (depending on details of phonological form). This applies to the syllabic liquids /l, r/ as well as vowels, and often manifests itself as a diphthongal vowel: for example, *e ~ ie, o ~ ô* (=/ᵘo/):

(21)	kladivo	'hammer'	kladív
	mesto	'town'	miest
	srdce	'heart'	sŕdc
	stopa	'trace'	stôp
	vlna	'wave'	vĺn

Despite the apparently processual nature of this alternation, Rubach (1993) argues for an analysis in which it is triggered phonologically, by an affix consisting of an 'abstract' lax vowel with no associated skeletal slot (a 'yer'). When final, such yers regularly trigger lengthening of the vowel of the previous syllable. All word-final yers are then deleted. This gives rise to what phonologists call an 'opaque' derivation, in that there can never be a surface form in which the triggering suffix (the yer) ever materializes. There is thus some pressure on proponents of such analyses to demonstrate that the system is learnable, compared to more surface-oriented alternatives.

Just as it is possible to see paradigmatic stress alternations, so vowel length may shift systematically across a paradigm. In (22) we see noun paradigms of certain nouns, *vrána* 'crow' and *jáma* 'pit', in Czech (this is not a regular phenomenon, only a feature of certain limited lexical classes; regular nouns do not exhibit any length alternations):

(22)   Case   Singular   Plural   Singular   Plural

       nominative   vrána   vrány   jáma   jámy
       genitive   vrány   vran   jámy   jam
       dative   vráně   vranám   jámě   jámám
       accusative   vránu   vrány   jámu   jámy
       locative   vráně   vranách   jámě   jámách
       instrumental vránou   vranami   jámou   jámami
       (NB: an accent here indicates a long vowel, not stress!)

3.6 Consonant length

Length alternations can affect consonants, too. A particularly interesting use of gemination is found in the verb system of Amharic, a Semitic language of Ethiopia.[4] As in other Semitic languages, the lexeme is built on a consonantal root (usually three in number, giving a 'triliteral root'). In many verbs we find gemination of the penultimate of these consonants: that is, the second for a triliteral root, the third for a quadriliteral (four-consonant) root. This is found throughout the inflectional and derivational system, including the formation of the stems for the perfect, imperfect, imperative, jussive, infinitive, instrumental, gerund and agentive (Type B). In other verbs, Type A, gemination is only found in the perfect (regarded as the basic stem form for Amharic verbs). Other verbs have gemination in the perfect and imperfect, Type C. Finally, a few verbs lack gemination. Examples of Type A (*mäkkärä* 'advise') and Type B (*fällägä* 'want') are given in (23):

(23)   mäkkärä   fällägä

      perfect   mäkkärä   fällägä
      imperfect   yəmäkral   yəfälləgal
      gerund   mäkro   fälləgo
      imperative   məkär   fälləg
      jussive   yəmkär   yəfälləg
      infinitive   mæmkær   mæfællæg
      agentive   mäkari   fällagi
      instrumental mämkärya   mäfällägya

3.7 Metathesis

Metathesis is the reordering of phonemes, as when in child speech or certain dialects the verb *ask* is pronounced /aks/. Metathesis often accompanies affixation (when it is frequently little more than a phonological repair of an illicit phonotactic combination resulting from the affixation), but on occasion it gives the impression of being the sole exponent of a morphological property. Clearly,

if it could be demonstrated that metathesis was a morphological exponent, this would demonstrate that a purely concatenative, affixal theory of morphology was inadequate.

A case that has been the subject of some discussion is that of the derivation of the 'actual' (essentially an imperfective) form of a verb from its 'non-actual' (perfective) form in certain Salishan languages, notably Saanich. The data in (24) are taken from Stonham 1994: 172:

(24)   Non-actual   Actual

   (a) se   se-ʔ   'send'
        wéqəs   wé-ʔ-qəs   'yawn'

   (b) t'sə   t'əs   'break something'
        q'k'ʷə   q'ək'ʷ   'straighten something'
        sc'ə   səc'   'whip something'

In the (a) examples the actual form is derived from the non-actual by infixation of -ʔ after the first nucleus of the stem. In the (b) forms we have metathesis of the second consonant and the vowel. Stonham points out that this CV metathesis occurs only with roots beginning with a cluster. He argues that the actual is formed by adding a mora to the first syllable. In the (a) cases this is achieved by closing the syllable with -ʔ. In the (b) cases a 'simpler' solution is to assume that consonants and vowels are segregated (cf. McCarthy 1989); in effect, that the linear ordering of vowels with respect to consonants is not fully determined. The non-actual forms are monomoraic, which means that the vowel must be syllable-final. However, the actual forms are bimoraic. This means that, instead of closing the syllable with -ʔ, the root can simply assign its second consonant to the second mora (note that there are no long vowels in the language).

This is an ingenious solution which skilfully appeals to phonological constraints apparent elsewhere in the language. However, even if this type of solution allows us to dispense with metathesis as a primitive operation, it does not dent the thesis that non-segmental phonological shape can be used as the exponence of a morphological property. First, suppose we grant that the Saanich lexicon contains a prefix consisting of just a single mora serving as the exponent of the 'actual' category. (How exactly you 'list' a mora in the lexicon is a question that needs investigating, but we will pass this by for the present.) We must then ensure that the grammar selects the metathesis solution for (24b) over glottal stop insertion. In Optimality Theory there are various plausible possibilities. For example, we could say that the constraints against epenthetic consonants and against onset clusters outrank the constraint against codas. However, Stonham points out that minimal words in Saanich are bimoraic (as is frequently the case cross-linguistically). Therefore, given the claim that vowels and consonants are segregated, and that their relative ordering is determined by syllable phonotactics, there must be a constraint in the morphology

stating that non-actual roots lacking vowels must not be bimoraic. But this is itself an instance of a morphological property being realized by purely phonological exponence – there is no way to characterize this in terms of addition of an affix.

3.8 Subtractive morphology

Another phenomenon which is very hard to analyse in terms of the addition of affixes is subtractive morphology, under which a form is derived from another form by deleting material. Dressler (1987) has discussed a number of such cases. A simple example is provided by agentive nouns in Russian derived from Latinate names of sciences or profession: *biologija* 'biology' *biolog* 'biologist', *agronomija* 'agronomy' *agronom* 'agronomist'. Here, a portion of the stem is deleted, *-ija*. Dressler points out that there is no justification for assuming the opposite direction of derivation.

3.9 Truncation

Related to subtractive morphology is the sort of shortening which is very widespread in evaluative morphology, as in the formation of diminutives of personal names: *Michael – Mike*, *Patricia – Trish*. This can regularly be analysed as the fitting of the original phoneme string of the word to a prosodically defined template. In this respect it is reminiscent of many forms of reduplication, in which it is the reduplicant which is often analysed as fitting over a template. Opinion is divided as to whether such evaluative formations reflect genuine morphological phenomena and processes (see Zwicky and Pullum 1987 for a dissenting view). Of potential relevance is the fact that such formations often reflect spelling pronunciations, as in *spec* (from *specification*) or *Ameslan* (from American Sign Language).

3.10 Replacive morphology

In structuralist morphemics the alternation between singular *man* and plural *men* would often be handled in terms of the replacement of part of a morpheme by another phoneme string, in this case /a/ by /e/. However, there are a good many ways in which such apophonic alternations might be handled. More interesting are cases in which there appears to be a paradigmatic relationship between affixes. Consider the case of *-ist* and *-ism* suffixation. We could take the forms *Marxist* and *Marxism* to be derived by adding either *-ist* or *-ism* to *Marx*. However, this would miss the point that a Marxist is not just someone with some arbitrary relationship to Marx, but rather one who practises Marxism. Thus, semantically at least, we can say that *Marxist* is motivated by

Marxism, not by *Marx*. But this would mean saying that *Marxist* is derived by replacing *-ist* with *-ism*.

4 Stem indexing

A final aspect of the morphological use of phonology is the way in which different stem forms of a word are used to signal morphological relations. Though not strictly speaking an instance of a morphological property realized as a morphophonological operation, it represents essentially the same kind of relationship. Lieber (1980) argued that it was possible to do without purely morphological diacritical markings on Latin verb stems, and that conjugation class membership could be established purely on the basis of the phonology of the main stem allomorph (listed in the lexical entry). She then concluded that morphological diacritics of this sort were universally unnecessary. This position was criticized by Spencer (1988a), and a much more detailed demonstration of the need for purely morphological indexing of stems has been made by Stump (1995a) from Sanskrit.

Many Sanskrit stems occur in three forms, depending on the nature of the vowel of the final syllable of the stem (an instance of ablaut). These are known traditionally as the vrddhi grade, guna grade and zero grade. The precise phonological shape assumed in these grades depends on a complex phenomenon involving vowel coalescence, sonorant vocalization and so on, but the basis is that the vrddhi grade has a long *-a:*, the guna grade has a short *-a*, and the zero grade has no *-a* vocalism. An example using the verb lexeme *pat* 'fall' is given in (25), and one involving a nasal alternation from the masculine declension of the possessive adjective *bhagavant* 'fortunate, blessed' is shown in (26) (ignoring accent):

(25) *pa:t* pa-pa:t-a   3sg. perf. act.   'has fallen' vrddhi
      pat   pat-ati   3sg. pres. indic. act. 'falls'   guna
      pt   apa-pt-at   3sg. aor. act.   'fell'   zero

(26) *bhagavant-* bhagavant-as   nom. pl.   guna
                    bhagavant-a:u nom./acc. du.
      bhagavat-   bhagavat-as   abl./gen. sg. or acc. pl.   zero
                    bhagavat-os   gen./loc./ du.

At the same time, various morphological properties or categories make appeal to different types of stem. In nominals, for instance, declensional forms are regularly built on two stems, referred to as Strong and Middle. Thus, in the possessive adjective *bhagavant*, the Strong stem is found in the nominative forms and in accusative singular and dual (but not plural) forms, with the Middle stem occurring elsewhere. Notice that this cannot be defined purely in

terms of the phonology of the case/number/gender suffixes, since formally identical suffixes may select different stems, as is seen with *-as* 'nom. pl.' (Strong) and *-as* 'abl./gen. sg. or acc. pl.' (Middle).

In (26), the Strong stem is the guna form, and the Middle stem is the zero form. However, this correspondence between morphologically defined stem type and ablaut type (vrdhhi, guna, zero) doesn't always hold. The Strong stem of the neuter noun *na:man* 'name', for instance, is in the vrddhi grade, not the guna, as seen in (27):

(27)   na:ma:n-i   'nom./acc. pl.'   na:ma:n-   vrddhi
       na:mn-a: 'instr. sg.'   na:mn-   zero

Some nominals have a third stem form, called 'Weakest'. In some adjectives the Weakest stem is suppletive, while in others it is the zero grade. In the noun *ahan* 'day', however, the Weakest stem is zero grade, the Strong stem is vrddhi, and the Middle stem is suppletive. In present and future active participles, the Strong stem is in the guna grade, while both Middle and Weakest are in zero grade (with differences in accent).

These kinds of data illustrate that it is not in general possible to predict the stem type from the morphophonology. Stump concludes that stems in general need to be indexed for the morphological function they fulfil. Where there is a regular relationship between morphophonological form and function, this can be stated as part of the stem-indexing rule, but in general such rules have to be kept separate from the morphophonological stem-formation rules. Such indexing rules may take the form shown approximately in (28) (where 'Class (V)' is an arbitrary feature I have created for labelling nominals such as *na:man* or *ahan*):

(28)   For lexeme L:
       where L is in Class (V), $\text{Stem}_{\text{Strong}}$ =   vrddhi(L)
       $\text{Stem}_{\text{Strong}}$ =   guna(L)
       $\text{Stem}_{\text{Middle}}$ =   zero(L)
       $\text{Stem}_{\text{Weakest}}$ =   zero(L)

The point here is that purely morphological properties within the organization of the inflectional system such as Strong, Middle and Weakest stem are realized by a complex interaction between phonological shape and purely morphological indexing in a fashion that cannot be handled in terms of affixation. Given that languages clearly have to appeal to such non-affixal relationships between stems, it should not come as any great surprise to find that stem allomorphy can be extended to include inflectional or derivational forms, giving rise to situations in which morphological properties which are normally expressed affixationally are realized as systematic morphophonological relationship, without the intermediary of affixation.

ACKNOWLEDGEMENT

NOTES

1 Throughout I shall use examples predominantly from inflection. For examples in derivational morphology of some of the operations discussed here see Beard, DERIVATION.

2 Interestingly, there seem to be no cases of infixation of true clitics (endoclitics; see Nevis 1984).

3 Brown et al. 1996, provides a defence of the paradigmatic approach to Russian stress, though it does not treat the alternations seen in (20) as a unitary phenomenon. It thus remains to be seen whether the behaviour of monosyllabic neuter (for Brown et al., 'Class IV') roots is systematic or accidental.

4 The data, though not the terminology, are based on Titov 1971: 99f. I am grateful to Dick Hayward for discussion of the examples and for explaining the standard terminology to me.