1. Background

A speech synthesizer is a machine that inputs a stream of text and outputs a speech signal. This paper will discuss a small piece of how words are converted to phonemes.

Typically words are converted to phonemes in one of two ways: either by looking the words up in a dictionary (with possibly some limited morphological analysis), or by sounding the words out from their spelling using basic principles.

- Dictionary Lookup
- Letter to Sound

Both approaches have their advantages and disadvantages; dictionary lookup fails for unknown words (e.g., proper nouns) and letter to sound rules fail for irregular words, which are all too common in English. Most speech synthesizers adopt a hybrid strategy, using the dictionary when possible and turning to letter to sound rules for the rest. I discussed letter to sound rules at the last meeting of the ACL [Church]; this paper will report on some new dictionary lookup approaches, with an emphasis on morphology.

Morphological decomposition is used to reduce the size of the dictionary and to increase coverage. Instead of storing all possible words, the system can store just a lexicon of morphemes and save a factor of 10 [Jon Allen (personal communication)] in storage. Now when the system is given a word and asked to determine pronunciation, the system decomposes the word into known morphemes, looks up the pronunciation of each of the pieces and combines the results.

2. MITalk Decomp

The best known morphological decomposition system is the Decomp module in the MITalk synthesizer [Allen et. al.]. This system attempted to parse an input word such as formally into morphemes: form, -al and -ly. It was assumed that morphemes are concatenated together (like “beads on a string”) a

The types of morphemes were:

1. Prefixes (pref): UNtie, PERmit, REDuce
2. Suffixes
   a. Derivational (derv): laxITY, existENCE, softNESS, kingDOM
   b. Inflectional (infl): boatING, toastED, coatS, manS
3. Roots
   a. Free (root): sray, squeeze, large
   b. Absolute (absl): the, than, but
   c. Left-Bound (lbrt): rePEl, conCEIVE
   d. Right-Bound (rbrt): CRIMINal, TOLERance
   e. Strong (root): women, rang

Costs were placed on the arcs to alleviate overgeneration. Note that the grammar produces quite a number of spurious analyses. For example, not only would formally be analyzed as form-al-ly but it would also be analyzed as form-ally and for-mal-ly. The cost mechanism blocks these spurious analyses by assigning compounding a higher cost than suffixation and therefore favoring the desired analysis. Although the cost mechanism handles a large number of cases, it would be better to aim toward a tighter grammar of morphology which did not overgenerate so badly.
The MITalk Decomp program performed its task quite well; it could analyze 95% of running text [Allen (personal communication)]. In order to achieve this level of performance, the authors of Decomp made a conscious decision not to deal with stress alternations (festive / festivity), vowel shift and tensing (divine / divinity), and other phonological rules associated with latinate morphology. Basically, there was only one rule for combining the pronunciations of morphological pieces: simple concatenation with a few simple rules to account for spelling alternations at the juncture:

- Silent e deletes before a vocalic suffix: observe + ance -> observance
- Consonant doubles before a vocalic suffix: red + est -> reddest
- y → i before a suffix: glory + ous → glorious
- y deletes before a suffix starting with i: harmony + ize -> harmonize

All affixes were assumed to be stress neutral. Words like festivity and divinity which require a richer understanding of the interaction of morphology and phonology were entered into the lexicon as exceptions.

The decision not to handle more complicated morphological and phonological rules was based on the belief that it is hard to do an adequate job and that it wasn't necessary to do so because the rules are not very productive and hence it is possible (and practical) to list all of the derived forms in the lexicon. I'd like to believe that morphology and phonology have progressed enough over the past ten years that this argument does not have as much force as it did. Nevertheless, I have to admit that the payoff may be marginal, especially if measured in short term savings in the size of the lexicon and memory costs. The real value in the enterprise is more long term; I am betting that pushing the theoretical linguistic understanding with a demanding application such as speech synthesis will uncover some new insights.

3. Types of Morphological Combination

It has long been recognized that "stress-shifting" morphology (e.g., divinity) differs in quite a number of respects from "stress neutral" morphology (e.g., divine). It is a well-established convention to mark the "stress-shifting" morpheme boundary with a "" symbol and to mark the "stress-neutral" boundary with a "#" symbol. (Scare quotes are placed around "stress-shifting" and "stress-neutral" because these terms are probably not quite right.) This paper will also use the terms Level 1 and Level 2 to refer to the two types of morphological combination, respectively. This terminology is taken from the literature on Level Ordered Morphology and Phonology (e.g., [Mohanan]) which argues that "" boundary (level 1) morpheme is ordered before "#" boundary (level 2) morphology and that this ordering dependency has important theoretical implications.

It is worthwhile to review some of the well-known differences between "" boundaries and "#" boundaries. Informally "" morphemes such as in-, ad-, ab-, +al, +ity are (generally) derived from Latin whereas "#" morphemes such as #ness, #ly come from Greek and German. This historical trend is only a rough correlation and has numerous counter-examples (e.g., the German suffix -ist behaves like ""). The program uses the following set of prefixes and suffixes:

- Level 1 "" Prefixes: a, ab, ac, ad, af, ag, al, am, an, ap, ar, as, at, bi, col, com, con, cor, de, dif, dis, e, ec, ef, eg, el, em, en, er, es, ex, im, in, ir, is, ob, oc, of, per, pre, pro, re, suf, sur, sus, trans
- Level 1 "#" Suffixes: ability, able, aceous, acious, acity, acy, age, al, ality, ament, an, ance, ancy, ant, ar, artly, ary, ate, ation, ational, ator, atorial, atory, ature, bile, bility, ible, ble, bly, e, ea, ean, ear, edge, ee, ence, enty, ential, eous, ia, iac, ial, ian, lance, iant, iary, iate, iative, ician, icity, icize, ide, ident, ience, iency, ient, ificate, ification, ificative, ify, ion, ional, ionary, ious, isation, ish, ist, istic, itarian, ite, itty, itum, ival, ive, ivity, ization, ize, ize, isence, ulary, ment, mental, mentary, on, or, ory, osity, ous, ular, ularity, ure, ute, utive, y
- Level 2 "#" Prefixes: anti, co, de, for, mal, non, pre, sub, supra, tri, ultra, un
There is also a well-known precedence relation between + and #. With very few exceptions, # morphemes nest outside of + morphemes. Thus, we have non # [in + moral] but not *in + [non # moral]. The precedence relation yields some subtle (but correct) predictions. Observe that -able can be a level 1 affix in some cases (e.g., comparable) and a level 2 affix in others (e.g., employable). Notice the contrast between INcomparable and UNemployable; the + marked comparable takes the + marked prefix in+ whereas, in contrast, the # marked employable takes the # marked prefix un#. This same contrast is brought out by the famous pair: indistinguishable / undistinguishable. (This argument is no longer considered to be as convincing as it once was because of so-called bracketing paradoxes which will be discussed shortly.)

Word formation rules are also sensitive to the difference between + and #. Note that + morphemes can attach to bound morphemes (e.g., crimin + al), but # morphemes cannot (e.g., *crimin # ness, *crimin # ly, *crimin # hood). In addition, # morphemes attach more productively than + morphemes.

"It is clear that #ness attaches more productively to bases of the form Xous than does +ity; fabulosity is much "better" than fabulosity, and similarly for other pairs (dubiousness / dubiety, dubiosity). There are even cases where the +ity derivative is not merely worse, but impossible acrimonious / *acrinoniosity, euphonious / *euphonosity, famous / *famousosity. There is also the simple list test, which is still a good indicator. Walker (1936) lists fewer +ity derivatives than #ness derivatives of words of the form Xous." [Aronoff, pp. 37-38].

Aronoff continues to point out that the semantics of # boundaries tend to be more predictable and compositional than + boundaries. The meaning of callousness, for example, is more predictable from the meanings of callous and ness than the meanings of variety, notoriety and curiosity are from the meanings of their parts.

The following list summarizes some of the differences between + and #:

- + morphemes are (often) historically correlated with Latin; # with German and Greek
- + morphemes feed certain phonological rules (stress assignment, vowel shift); # do not.
- + morphemes take precedence over #
- + morphemes can attach to bound morphemes; # cannot
- + morphemes are less productive than #
- + morphemes have less predictable semantics than #

The remainder of the paper will be divided into two sections, the first will be concerned with level 1 morphology and the second with level 2 morphology and compounding. Level 1 morphology has been studied more heavily in the linguistics literature; level 2 is perhaps more important for practical applications, at least in the short term.

4. Morphological Decomposition of Level 1 Affixes

A number of the differences between + and # ought to be relevant in decomposing level 1 affixes and reducing the possibility of spurious derivations. Consider how the first difference mentioned above, historical correlation, could be used to improve a decomposition program. It is very easy, for example, for a decomposition program to decide erroneously that acclamation is derived from clam, meaning roughly the result of having been clammed up. If the program could somehow split the Latinate and non-Latinate vocabularies, then the program could know that -ation cannot be attached to clam because clam is not Latinate. The program accomplishes this by maintaining a short list of words marked with an ad hoc feature [−Latinate].

The program might perform even better if the Latinate vocabulary were split still further. Consider, for example, the split between words ending with -ent and those ending with -ant. The first class are likely to have variants ending with -ence and -ency and the second are likely to have variants ending with -ance and -ancy. It seems extremely implausible for an -ent word such as president to take an -ant suffix: *presidant, *presidance, *presidancy. Thus, it would be desirable to partition the Latinate vocabulary into quite a number of subsets, each with different possibilities for suffixation. But how do we do this without assigning ad hoc features such as [+Latinate], [+ent], [+ant], [+Declension 1], [+Declension 2], etc.?

Not only is the feature approach ad hoc, but it also missing an important asymmetry. Note that most words ending with -ency (e.g., presidency) are derived from words ending with -ent (e.g., president), and crucially not the other way around. The intuition that the relation "derived from" is asymmetric has some distributional support: notice that the percentage of words ending in -ency which are morphologically related to words ending in -ent is much larger than the percentage of words ending in -ent which are related to words ending in -ency. (The program estimates these percentages to be 73% (36/710) and 5% (36/710), respectively, using a procedure described below.)

This asymmetry is problematic for a concatenation model like MITalk's Decom, which would place presidency and president on equal footing, deriving both from preside.

Aronoff-style [Aronoff] truncation rules provide an attractive mechanism for accounting for the asymmetry. Recall that Aronoff proposed that nominee be derived from nominate by truncating the -ate suffix and attaching -ee in a single step. These truncation rules were necessary for him so that he could maintain his Word Based Hypothesis. The Word Based Hypothesis claims that words are formed from other words (possibly via truncation) and not from bound morphemes. Thus, in Aronoff's theory, there is no bound morpheme nomin-; there are only words (e.g., nominate and nominees). The generalizations that would be attributed to nominate in other
theories are captured in Aronoff’s system by his truncation rules. The program uses truncation rules to capture the symmetry in the ‘derived from’ relation by permitting -ent to be truncated before -ency, but not the other way around. Thus, presidency is derived from president — -ent + -ency, and president is not derived from presidency because does not truncate -ency before -ent. Truncation rules are subject to a number of constraints. In particular, truncation is only found at level 1; truncation cannot apply at level 2 because, as mentioned above, level 2 affixes attach to words, not bound (= truncated) morphemes.

How does the program decide which suffixes can be truncated and when? Let me introduce the notation -ency > -ent to mean (roughly) that words ending with -ency are likely to be derived from words ending with -ent. The precise status of the ‘>’ relation should be to be explored more fully. In some cases, the relation is a necessary condition; if presidency is derived from an English word then it must be derived from president. In other cases, the relationship expresses a possibility but not a necessity. For example, words ending in -ation may be related to words ending in -ate, but not necessarily. Marchand describes the relation as follows:

“The English vocabulary has been greatly enriched by borrowings, chiefly from Latin and French. In course of time, many related words which had come in as separate loans developed a derivational relation to each other, giving rise to derivative alternations. Such derivative alternations fall into three main groups.

Group A is represented by the pairs 1) -acy / 2) -ate (as piracy ~ pirate), 1) -ancy, -ency / 2) -ant, -ent (as militancy ~ militant, decency ~ decent), 1) -ization / 2) -ization, 1) -ification / 2) -ify (as identification ~ identify), 1) -ability / 2) -able (as respectability ~ respectable), 1) -ibility / 2) -ible as (convertibility ~ convertible), 1) -ician / 2) -ic(s) (as statistician ~ statistics), 1) -ity / 2) -ic (as catholicity ~ catholic), 1) -ity / 2) -ine (salinity ~ saline).

If 1) is a derivation from an English word, the only possible word is 2), i.e., if piracy is a derivative from an English word, only pirate is possible. The statement does not imply that for every 1) there must be a 2). 1) may be a loan, or it may be formed on a Latin basis without any regard to the existence of an English word at all (enormity, for instance, is so coined). Nor does the derivational principle involve the existence of a 1) for every 2) (many words in -able or -ine are not matched by words in -ability resp. -inity).

Group B is represented by the pairs 1) -ation / 2) -ate (as creation ~ create), 1) -etry / 2) -er (as carpentry ~ carpenter), 1) -ress / 2) -er (as murderess ~ murderer), 1) -ious / 2) -ion (as ambitious ~ ambition, 1) -ous and 2) -ion (as vexatious ~ vexation).

If 1) is a derivation from another English word, the derivational pattern 1) from 2) is possible, but not necessary. A derivative in -ation such as reforestation is connected with reforest, a derivative such as swannery is connected with swan, archeress is connected with archer, robustness is extended from robust (but otherwise an adj in -ous derived from a sb points to the sb ending in -ion, i.e. we have really type A).

Group C is nothing but a variant of A and concerns adjs in -ious as flirtatious. Originally deriving from sbs in -ation, the type is now equally connected with the unextended radical, i.e. flirt (the older derivation ostentatious 1658 has not entered this latter derivational connection).” [Marchand, pp. 165-166]

For pragmatic purposes, the program assumes that there is only one ‘>’ relation, not three as Marchand suggests, and that the relation can be estimated statistically as follows:

\[
\frac{\text{number of words ending with both suffix}_1 \text{ and suffix}_2}{\text{number of words ending with suffix}_1}
\]

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The decomposition program uses the table above to decide whether suffixes can be truncated and when. Consider the word presidency. The program notices that this word ends in -ency so it looks in the table and discovers that -ency alternates with -ent (13%), -ence (24%), -e (14%) and -0 (12%). The program tries to replace -ency with each of these sequentially until it finds a word in the dictionary. In this case, it will succeed on the first try when it replaces -ency with -ent and finds that the result president is a word in the dictionary.

Level 1 prefixes are processed through an analogous procedure, so that effect, for example, is derived from defect by truncating the ef- prefix and adding the prefix de-. The truncation mechanism is not generally employed by most authors for prefixing, and it may be a mistake to do so, but I used it anyways, mostly because it was available and filled a practical need.

The resulting decomposition program has been used to construct a forest of related words as illustrated below:

```plaintext
(38 infect
 (affect (affectation)
 (affection (affectionate))
 (affective (affectivity))
 (disaffection)
 (confect (confection) (confectionary))
 (defect (defection) (defective)
 (effect (effective (ineffective)))
 (disinfect (disinfectant))
 (infection)
 (infectious)
 (inflective)
 (reflect (perfect (imperfect (imperfection))
 (perfective (perfectible))
 (prefect (prefecture))
 (reflection)
 (refectory (prefectorial)))

The forest was constructed by applying the decomposition procedure to every word in the dictionary and then indexing the results to show which forms were derived from which stems. Thus 38 words were found to be related to the stem port and 36 words were found to be related to infect. These results seem extremely promising; most of the relations appear to agree very closely with intuition.

Now that we have a fairly accurate method of decomposing words at level 1, how can this be put to practical use? For assigning stress, it would be useful to know the weight of the syllables in the stem. This is particularly necessary before so-called weak retraction suffixes (e.g., -ent, -ant, -ence, -able, ance, al, ous, ary). General principles of stress retraction (e.g., [Liberman and Prince]), predict strong retractors (e.g., -ate, -ation) always back the stress up regardless of syllable weight (degrade / degradation), whereas weak retractors do so only if the preceding syllable is light (refer / referent with a light syllable before -ent, as opposed to cohère / coherent with a heavy syllable before -ent).

Given syllable weight, it is relatively well-understood how to assign stress. A large number of phonological studies (e.g., [Chomsky and Halle], [Liberman and Prince], [Hayes]) outline a deterministic procedure for assigning stress from the weight representation and the number of extrametrical syllables (i.e., nouns, 0 for verbs). A version of this procedure was implemented by Richard Sproat last summer, and was discussed at the last ACL meeting [Church].

It is generally believed that syllable weight is derivable from underlying vowel length and the number of consonants, but if one is trying to assign stress from the spelling, it can be difficult to know the vowel length and the number of consonants. The fact that inference has a heavy penultimate syllable and that inference has a light penultimate syllable is extremely difficult to determine from the spelling. It would be considerably easier if syllable weight (or some correlate thereof such as vowel length) were marked in a lexicon of stems, so that the program could determine syllable weight by decomposing a word into its peices, look them up in a morpheme lexicon, and then re-combine the results appropriately.

Not only is it convenient for practical application to assume that stems are marked in the lexicon for syllable weight, but it may be necessary for linguistic reasons as well. Consider the stress alternation confide / confidence. This alternation is problematic because the i in confide seems to be underlyingly long whereas the i in confidence seems to be underlyingly short, and yet, the
two stems ought to share the same underlying form since the
two words are morphologically related to one another. The
solution to the confidence puzzle, I believe, is to say that the
stem -fide is marked in the lexicon as underlyingly light at least
with respect to stress retraction (and to account for the tense
vowel in confide in some other way (Church forthcoming)).
The table below is presented as evidence that the confidence
alternation is determined, at least in part, by some sort of lexical
marking on stems. Note, for example, that -fer, -cel, -side, and
-fide words display the confidence alternation, but -here, -pel,
and -pose words do not.

| alternation | refer  | refer   | confer | confer   | infer  | inference | defer  | deference|
|-------------|--------|---------|--------|----------|--------|-----------|--------|-----------|
|             | reference | reference | conference | conference | inference | inference | deference | deference |
| excel       | excel   | excellence | excellence | excellency |
| reside      | resident | residency | residency |
| preside     | president | presidency | presidency |

| no alternation | adhere | adherent | adherence | adhesive |
|----------------|--------|---------|----------|---------|
|                | cohere | coherent | coherence | cohesive |
|                | inhire | inherent | inherence | inhesion |
|                | expel  | expellent | expellant |
|                | repel  | repellant | propellant |
|                | propel | propellant | propellant |
|                | expose | exposal | exposure | expository |
|                | dispose | disposal | disposition | dispository |
|                | propose | proposal | composure |

Assume the lexicon divides stems into at least two classes:

- Retraction Class I Stems (light): -fer, -cel, -side, -fide,
- main, -vail, -note, -cede, -pete, -pair, -pare
- Retraction Class II Stems (heavy): -here, -pel, -pose, -hale,
- pale, -grade, -vade, -flame, -suade, -place, -plore, -void,
- clude, -prove, -some, -fuse, -duce

where class I stems show stress alternations before weak
retracting suffixes and class II stems do not.

This concludes what I wanted to say about level 1
decomposition. In summary, this section presented Aronoff-style
truncation rules as an alternative to MITalk-style concatenation
rules. Truncation rules have the advantage that they preserve
the asymmetry in the ‘derived from’ relation, and that they
correctly partition the lexicon into classes such as [+ent] and
[+ant] without introducing unnecessary ad hoc features such as
[+ent] and [+ant]. Some results of the new decomposition
procedure were presented, and they seem to agree very closely
with intuition. It was suggested that the decomposition
procedure could be used in stress assignment, by decomposing
words into morphemes, look up the syllable weight of the pieces
in a morpheme lexicon, and then recombine the results
appropriately. This last suggestion has not yet been fully
implemented.

5. Level 2 and Compounding

Most of the linguistic literature deals with level 1 where we find
extremely interesting stress alternations and vowel shifts and so
forth. Generally speaking, the phonology of level 2 and
compounding is believed to be relatively fairly straightforward.

6. Are Level 2 Affixes Really Stress Neutral?

It might be possible to extend this position to its logical extreme
and say that all level 2 affixes stress like compounds, and thus
completely do away with the concept of stress neutral affixes.

- Compound Theory: (All) Level 2 affixes are stressed just like
compounds; they receive main stress on the left in nouns and
main stress on the right in verbs and adjectives.

- Stress Neutral Theory: (At least some) Level 2 affixes are
stress neutral; they are simply concatenated onto the stem (a
là MITalk’s Decomp).

The compound theory has much to recommend it. Indeed most
level 2 prefixes are like under-, anti- and super- follow the general compound pattern where stress is
assigned the to the left member in nouns and to the right in
verbs and adjectives.

| Noun | Adjective |
|------|-----------|
| underdog | underdog |
| antifreeze | antifreeze |
| supermarket | superimpulse |

Admittedly, there are a number of nominal compounds like
pro-life and anti-abortion which take right stress, presumably
because the semantics of the left member takes on a semi-
adicatival status. Notice, for example, that the word antimatter
has two stress patterns, one with main stress on the left and one with main stress on the right, just like well-known compound blackboard. With left stress, the compound takes non-compositional semantics and with right stress the compound has a more compositional meaning. These facts suggest that the compound theory can be maintained to account for cases like pro-life, but only if the compound stress rules are refined to take the semantic facts into account.

Level 2 suffixes provide additional support for the compound theory. Consider suffixes like *ment, hood, ship and ness which appear to support the the stress neutral theory because they never receive main stress. But, they can also be accounted for under the compound theory because they form nouns, and therefore the main stress would be expected to fall on the left. Moreover, consider the level 2 adjectival suffixes -istic and -mental. These suffixes refute the stress neutral theory because they take the main stress, but they are no problem for the compound stress theory which predicts that adjectival compounds should receive main stress on the right.

7. The Super-Puzzle and Compound Stress

In attempting to include prefixes as a subcase of compound stress, I did stumble over a very interesting problem in the theory of compound stress. Consider the contrast between superconductor and superconductivity. Although both compounds are nominal, the first takes primary stress on the left member and the second takes stress on the right member. Upon further investigation, it appears than many compounds ending with level 1 suffixes (e.g., -ity, -ation) take primary stress on the right member. For example, here is a breakdown of compounds ending with the letters ion. Note the strong tendency for primary stress to end up on the right member.1

- Left-Dominant: intersession, outstation, midsession
- Right-Dominant: intercommunion, supervision, anteeversion, intersession, superession, intermission, echolocation, intercolumniation, contravallation, overpopulation, interlunation, intermigration, overcompensation, after sensation, super fetation, superrelevance, interaction, intercession, contra distinction, superinduction, superconduction, under production, contraposition, superposition, interposition, postposition, interlocation, counterrevolution
- Neither: tourbillion, interrogation, foreordination, redintegration forestation, electrodeposition

Thus, it appears that compounds ending with a level 1 suffix take right stress. If correct, however, the generalization is a puzzle for the level ordering hypothesis, which assumes that the stress rules of level 1 are opaque to the stress rules of level 2 and compounding. In other words, level ordering suggests a structure like superconductivity where level 1 takes precedence over level 2 and compounding, but stress assignment requires a different structure [superconductivity] where the compound stress rule applies before the level 1 suffix is analyzed.

In this sense, words like superconductivity are very much like the well-known bracketing paradox ungrammaticality, where level ordering suggests one structure [ungrammaticality] un# is a level 2 prefix which must scope outside of +ity with is a level 1 prefix) and syntactic/semantic interpretation (LF) requires another [ungrammaticality] (un# attaches to adjectives and not to nouns). Note that stress assignment seems to side with the syntactic/semantic arguments in suggesting a left branching structure that violates level ordering.

A solution to these bracketing paradoxes becomes apparent when we consider nominal Greek compounds like psychobiology with three or more morphemes. Notice that these compounds systematically take main stress on the middle morpheme.

Aeroneurosis, aerothermodynamics, astrobiology, astrogalography, astrophotography, autobiograp hic, biotechnology, chromolithography, chronobiology, cryobiology, diageotropism, electroanalysis, electrocardiogram, electrocardiograph, electrodialysis, electrodynamometer, electroencephalogram, electroencephalograph, electroencephalography, electrophysiology, endoparasite, epidi oscope, geochronology, geomorphology, heterochromatin, heterochromosome, histopathology, hypnoanalysis, magnetohydrodynamics, metaphysician, metapsychology, microanalysis, microorganism, microbiology, micrometeorology, micropaleontology, microparame sie, microphotograph, microphotography, microphotograph, microphotography, microphotography, microphotography, multivibrator, myocardigraph, neoorthodoxy, neuropathology, neurophysiology, orthohaemoglobin, otolaryngology, paleoethnobotany, parahydrogen, parapsychology, photochronograph, photoelectrotype, photogeology, photolithograph, photolithography, photomicrograph, photopolymer, phototelegraphy, phototypography, photozo nograph, photozoography, pneumoencephalogram, pneumoencephalography, psychoanalyse, psychoanalysis, psychop athology, psychopharmacology, psychophysics, radioautograph, radiobiology, radiocimicrometer, radiotelegram, radiotelegraph, radiotelegraphy, radiotelemetry, radiotelephone, radiotelephony, semidiameter, semiparasite, spectrohelio graph, spectrophotograph, stereoisomer, stereoisomerism, telephotography, telespectroscope, telespectroscope, teletype writer, thermobarograph, thermobarometer, ultramicrometer, ultramicroscope, ultramicroscopy

Assume that compounds take stress on the right member when it is branching (bi-morphemic). Thus, psychobiology takes main stress on the biology because it is branching.

Let me suggest further that this same sort of explanation might carry over to explain the stress in the bracketing paradoxes such as superconductivity and ungrammaticality where I claim that the right piece is 'branching' in order to account for the fact that main stress ends up on the right half.2 Note that I am

1. These suffixes cannot be level 1, because they don’t force the secondary stress to fall two syllables before the main stress: *départimental (cf., dégradation).

2. None of the left dominant words above end in the suffix +ion. Note, for example, the contrast between inter-session and inter-est-ion. The left dominant case does not end in the suffix +ion; the right dominant case does.

3. Almost all of these exceptions are due to errors in morphological decomposition algorithm. Tour # billion, inter # rotation, fore # station, and electrode # position are all incorrect analyses. It is highly unusual for the algorithm to make this many mistakes.
using the lexical category prominence rule in order to let one bit of information [+branching] pass through the opacity imposed by level ordering.

8. Conclusion

Two new ideas in machine morphological decomposition were presented. The discussion of level 1 proposed the application of Aronoff-style truncation rules as an effective means to capture the asymmetry in the 'derived from' relation. Secondly, the discussion of level 2 proposed ideas from the literature on compound stress as an alternative to the stress neutral approach taken in MITalk's Decomp.

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4. The problem is to define 'branching' so that it gets the right results. I don't want to say that superconductor is branching, because that would incorrectly predict main stress on conductor. I don't know how to define branching to achieve the desired results, though I believe that this approach is extremely promising.