Distribution of stress patterns among English suffixes : partial ordering theory vs. stochastic OT

Distribution of Stress Patterns among English Suffixes: Partial Ordering Theory vs. Stochastic OT

Hideki Zamma

1 Introduction

The goal of this paper is to examine how much the actual distribution of stress type among suffixes corresponds to the one theoretically predicted by Partial Ordering Theory (cf. Anttila, 2002, Anttila and Cho, 1998). I further examine if stochastic OT (cf. Boersma, 1998, Boersma and Hayes, 2001) — similar but more flexible reranking approach — can predict the distribution better than Partial Ordering Theory does.

In Zamma (2005a), it is proposed that the five stress patterns among English Class 1 suffixes can be properly accommodated within the framework of Partial Ordering Theory. Based on Optimality Theory (cf. Prince and Smolensky, 1993), this theory assumes that constraint ranking can be different among subgroups in the lexicon of a language: different rankings naturally lead to different phonological outcomes. I will summarize the analysis of English stress patterns in the next section.

This approach raises a further issue. Since factorial typology produces a limited number of logically possible rankings among constraints, and each suffix is assumed to have one particular ranking among possible ones, the proportion of rankings that produce a particular pattern might correspond to the proportion of Class 1 suffixes which show a particular stress pattern. Anttila (1997), actually, claims that the proportion of forms in Finnish genitive plurals corresponds to the proportion of rankings which produce each form. In Section 3, we will check to see if this theoretical prediction matches actual distribution in the English cases as well by examining the stress data of various suffixes given by Fudge (1984).

Statistic analysis does not show that the actual proportion completely matches the prediction, however. In Section 4, we thus examine to see if a more flexible reranking approach such as stochastic OT (cf. Boersma, 1998, Boersma and Hayes, 2001) will do a better job for the sake of precise prediction. Section 5 concludes the paper.

2 Possible Stress Patterns and Partial Ordering Theory

As summarized by Zamma (2003, 2005a), English has the following five major stress patterns; extrametrical (where stress falls on the antepenult if the penult is light as in (1a)), non-extrametrical (where stress falls on the light penult as in (1b)), non-retracting (where stress falls on the last syllable as in (2a-d)), strongly-retracting (where stress falls on the antepenult as in (3a)), and weakly-retracting (where stress falls on the penult if it is heavy as in (3b)). Representative suffixes of each pattern are summarized in (4).

(1) a. (nâtu)<ral> (hûmo)<rous> (dômi)<nant> (âddi)<tive>
b. alco(hôli)<c> a(tômi)<c> ti(tâni)<c> sym(phôni)<c>[1]

(2) a. Jàpanése, Chìnése, Vìetnamése, Pòrtuguése, jòurnalése
b. ènginéer, vòluntéer, pìonéer, mòuntainéer, àuctionéer, pùppetéer
c. àrabésque, Ròmanésque, pìcarésque, pìcturésque, gròtésque
d. nòvelétte, kìtchenétte, màrionétte, màisonétte, cìgarétte

(3) a. désignàte, démonstràte, cônfiscàte; sátisfỳ, récognìze, ânecdòte
b. ellîpsòid, mollûscòid, stalâgmìte, eleméntary, perfûnctory[2]

(4) a. extrametrical suffixes: -ity, -ion, -(i)an, -al, -ous, -ive, etc.
b. non-extrametrical suffixes: -ic, -id, etc.
c. non-retracting suffixes: -ese, -eer, -esque, -ette, etc.
d. strongly retracted suffixes: -ate, -(i)fy, -ize, etc.
e. weakly retracted suffixes: -oid, -ite, -ary, -ory, etc.

These various stress patterns can be elegantly accounted for in the framework of Partial Ordering Theory. In this theory, it is assumed that the 'core' of the grammar of a language is only partially determined. The remaining undetermined parts are thus fixed differently depending on the subgroup of the language, such as parts of speech, word classes, inflectional forms, etc. In other words, suffixes can have different constraint rankings with respect to each other, in terms of Optimality Theory.

First of all, the five constraints in (5) are necessary to account for English stress

---

[1] The final consonant nonetheless undergoes so-called extrasyllabicity (cf. Hayes, 1980).

[2] The final *y* in *-ory* and *-ary* is considered a glide (cf. Chomsky and Halle, 1968, Liberman and Prince, 1977).

assignment in general, and the five stress patterns can be identified in the characteristic rankings among them given in (6) (cf. Zamma, 2005a).

(5) a. ALIGN-R: Primary stress should be right-aligned.
b. EXTRAMETRICALITY (EM): The final syllable is extrametrical.
c. NONFINALITY (NONFIN): Primary stress does not fall on the final syllable.
d. *CLASH: Stresses should not be on adjacent syllables.
e. WEIGHT-TO-STRESS PRINCIPLE (WSP): A heavy syllable should be stressed.

(6) a. extrametrical: EM ≫ ALIGN-R
b. non-extrametrical: ALIGN-R ≫ EM
c. non-retracting: ALIGN-R ≫ NONFINALITY
d. Strong Retraction: NONFINALITY ≫ ALIGN-R PLUS
*CLASH ≫ WSP, ALIGN-R
e. Weak Retraction: NONFINALITY ≫ ALIGN-R PLUS
either WSP ≫ *CLASH or ALIGN-R ≫ *CLASH

As argued in Zamma (2005a), none of the constraint interactions other than the ones in (6) produces any phonological alternation. In other words, it is only the rankings in (6) that are responsible for producing the difference among the five stress patterns. Note in (6d) and (6e) that the ranking in the first line just makes the word undergo retraction, and that the one in the second line specifies its type. There are more constraints which are fixed in English in general, which creates 'Englishness' compared to other languages, but I will omit them for the sake of page restriction.

It is also pointed out that possible stress patterns can be predicted by the rhyme structure of the suffix. When it constitutes a heavy suffix (to be precise, when it is a heavy open syllable (henceforth H(VV)), the stress pattern would be either non-retracting, Strong Retraction, or Weak Retraction. Moreover, due to optionality of extrasyllabicity of a heavy closed syllable (henceforth H(VC)), this particular type of syllable can have any of the five stress patterns. I will summarize possible stress patterns with respect to the rhyme structure in the Appendix, in relation to possible rankings among the five constraints. (Since one of the ranking is assumed to be ranked consistently (i.e. EM ≫ *CLASH), the number of possible rankings is 5! / 2 = 60. See Zamma (2005a) for the detail.)

Each of the five patterns observed for English suffixes can then be analyzed as emerging from the particular rankings shown in the Appendix:

(7)

	rankings in the Appendix
extrametrical	L: 13-36, 40-45, 47-48, 52-57, 59-60; H(VC): 13-36
non-extrametrical	L: 1-12, 37-39, 46, 49-51, 58
non-retracting	H: 1-18, 25-26, 29, 31-32, 35, 49-53, 56
Strong Retraction	H: 21-22, 27-28, 30, 42-43
Weak Retraction	H: 19-20, 23-24, 33-34, 36-41, 44-48, 54-55, 57-60

3. Actual Proportions of Stress Patterns

3.1 A Prediction by the Theory

As we have seen, a partial ordering analysis correctly predicts the actual stress patterns observed in English from the possible constraint rankings. Looking at the table in (7), however, another issue surfaces: Is it possible to predict the proportion of each pattern by counting the number of their rankings? Since an extrametrical pattern has more rankings in (7) than a non-extrametrical one, for example, it is possible to predict that more extrametrical suffixes than non-extrametrical ones will appear. In fact, Anttila (1997) argues that, in a partial ordering analysis, the proportion of forms in Finnish genitive plurals correlates fairly well with that of the rankings which lead to each form. Can we make a similar prediction for English stress patterns?

Imagine a situation where a suffix which constitutes a final light syllable is about to be given a certain ranking. Given the 60 logically possible rankings in the Appendix, the suffix's chance of having a non-extrametrical property is 20/60, as that property is found in 20 rankings (these are checked in the column 'A $\gg$ E'). The same probability is predicted for other suffixes with a similar shape. In total, the probability of suffixes with this particular rhyme structure becoming non-extrametrical is 20/60 = 1/3 (i.e. 33.3%).

The same calculation will apply to suffixes with other rhyme structures in regard to other stress patterns. In theory, then, it is possible to predict that the proportion of suffixes with a particular stress pattern will correlate with that of the ranking for that pattern. Is this prediction borne out in actual distribution?

First, the numbers of rankings appearing in each pattern (7) are listed in (8).

(8)

	EM	non-EM	non-R	SR	WR
L	40/60 (66.7%)	20/60 (33.3%)	n.a.	n.a.	n.a.
H(VV)	n.a.	n.a.	30/60 (50.0%)	7/60 (11.7%)	23/60 (38.3%)
H(VC)	12/60 (20.0%)	n.a.	24/60 (40.0%)	4.5/60 (7.5%)	19.5/60 (32.5%)

As for the syllable structure H(VC), those rankings that have two possible patterns are counted as half for each; that is, rankings numbered 13 to 36 in the Appendix are counted as 0.5 for 'EM' and 0.5 for either 'non-R', 'SR', or 'WR'.

Note that it is unnecessary to make a comparison of syllable structure within a stress type (i.e. within a column in (8)). This follows from the arbitrariness of suffix form: the syllable structure of a suffix is completely arbitrary, whereas stress is dependent on the shape of the suffix.

The number of words with a given suffix are not taken into account. Rather, only the number of 'types' is considered, and not 'tokens'. This is because each suffix is considered to have a particular ranking, irrespective of how many words contain it. Thus, counting the number of total words (i.e. 'tokens') is irrelevant for our purposes: only the number of suffixes (i.e. 'types') with respect to a particular stress pattern is important. Note also that the number of words is heavily influenced by morphological factors such as 'productivity'. The tokens for suffixes like *-oid* and *-ite* is quite large, for example, but it depends on the amount of materials that chemists and geologists find in the universe.

3.2 Observation and Examination

In order to determine if the actual proportion of suffix stress patterns corresponds to the prediction (8), research was conducted on a relatively large number of suffixes listed in Fudge (1984) — a comprehensive study of English suffixes and compoundforming elements (such as *-graph*) in terms of stress assignment. All the stress-shifting suffixes were re-examined in order to classify them into one of the five categories given in (4). This re-examination was necessary because the classification of suffixes by Fudge is different from the one offered here and rather more complicated.[3]

There are, however, several caveats to this investigation. First, we just follow Fudge in identifying suffixes, some of which might be regarded as dubious. Determining what a true suffix is and is not requires an extremely careful study which far exceeds the scope of this article. Moreover, the classification of suffixes was based only on the data given in Fudge. This might be the reason why some cannot be determined with respect to retraction type, as we see below. Although there are limitations, we present what follows as a first trial for calculating the proportion of stress types among suffixes. A more comprehensive study on the entire English lexicon will complete the enterprise by excluding dubious suffixes and providing definitive data for unclear cases.

The results of the classification are as follows:

[3] Fudge categorizes suffixes as to how far away primary stress is placed from the suffix, rather than from the right edge of the word — irrespective of the number of syllables of the suffix and/or whether it carries secondary stress. Consequently, extrametrical suffixes (e.g. *-al*) and Weak Retraction suffixes (e.g. *-oid*) are both categorized as pre-stressed 2, placing primary stress on the second syllable preceding the suffix. Furthermore, his categorization is sometimes too descriptive. For example, *-ate* is categoried as having a 'mixed' pattern of autostressed (i.e. non-retracting) and pre-stressed 2. It is possible, however, to analyze this suffix only as a Strong Retraction suffix, since all non-retracting examples are disyllabic (as Fudge himself notices), hence immune to retraction so that a degenerate foot is *not* produced (e.g. **(crê)(àte),* cf. Zamma, 1993).

(9)

type	suffixes	total
extrametrical	L: -age, -al, -an, -er/-or, -ice, -ion, -is, -ity, -ive, -or$_{adj}$, -our, -ous, -ure, -y; H(VC): -able, -ant/-ent, -ist, -ment	L: 14 H(VC): 4
non-extrametrical	L: -ic, -id, -ish$_{v}$	L: 3
non-retracting	L: -et; H(VV): -ade, -aire, -aise, -ee, -een, -eer, -ese, -eur, -ier, -ine[i:n], -ique, -ise$_{n}$, -oo, -oon, -teen, -ute; H(VC): -elle, -enne, -esce, -esque, -esse, -ette, -ness$_{place}$	L: 1 H(VV): 16 H(VC): 7
Strong Retraction	L: -ad*, -gon; H(VV): -ate, -cide, -ene, -erie*, -fy, -ine$_{n}$[ain], -ite, -ize, -oir, -ose, -tude; H(VC): -ast*, -ism	L:1.5 H(VV): 10.5 H(VC): 1.5
Weak Retraction	L: -ad*; H(VV): -ée, -erie*, -ide, -ile, -ine$_{adj}$[ain], -ine$_{chemistry}$[i:n], -oid, -on, -ory; H(VC): -ary, -ast*, -ery	L: 0.5 H(VV): 8.5 H(VC): 2.5
total		L: 20 H(VV): 35 H(VC): 15

Homonymous suffixes are counted separately only when they show different stress behavior. This is because the stress behavior of some forms is often the same, except for minute differences such as subjectivity to vowel reduction. For example, both adjective- and verb-forming *-ate* undergo Strong Retraction, although only the former sporadically reduces the suffixal vowel (*private*), but not the latter (*activate*). These suffixes are thus counted as one, not two. Other homonymous suffixes, on the other hand, show a different behavior depending on meaning or the part of speech they belong to; thus while the chemical-noun-forming *-ine* [i:n] is retracting (e.g. *glýcerìne),* the usual nominal *-ine* is not (e.g. *tàmbouríne*). These suffixes are counted separetely.

As mentioned earlier, sometimes not enough data was found to determine which category a suffix belongs to, SR or WR. In these cases, 0.5 was counted for each of the two possible types, indicated by '*' to such suffixes in (9).

It should be noted that (9) contains several suffixes which are usually classified as belonging to Class 2: *-er/-or, -y, -able, -ment, -ist, -ism, -ize,* etc. The reason is that they can be attached to base roots — typical Class 1 behavior — in which case primary stress cannot naturally be preserved from the base, hence must be assigned anew. The problem of 'dual membership' has been pointed out by several researchers in the literature (e.g. Aronoff, 1976, Selkirk, 1982, Fudge, 1984, Szpyra, 1989, Giegerich, 1999, Zamma, 2005b, etc.).

To make the comparison between (8) and (9) clearer, let us summarize the results in (10). The percentages in the second line are those predicted by the theory in (8).

(10)

	EM	non-EM	non-R	SR	WR	total
L	14 (70.0%) **66.7%**	3 (15.0%) **33.3%**	1 (5.0%) **0%**	1.5 (7.5%) **0%**	0.5 (2.5%) **0%**	20
H(VV)	n.a. **0%**	n.a. **0%**	16 (45.7%) **50.0%**	10.5 (30.0%) **11.7%**	8.5 (24.3%) **38.3%**	35
H(VC)	4 (26.7%) **20.0%**	n.a. **0%**	7 (46.7%) **40.0%**	1.5 (10.0%) **7.5%**	2.5 (16.7%) **32.5%**	15

Informally speaking, the results are somewhat encouraging. Some of the cells show numbers relatively close to the prediction (e.g. extrametrical L, extrametrical H(VC), non-retracting H(VV), non-retracting H(VC), and strongly retracted H(VC)), whereas others are slightly less so (e.g. non-extrametrical L, weakly-retracted H(VV), and weakly-retracted H(VC)). Only one strongly exceeds the prediction (strongly-retracting H(VV)). This comparison becomes even clearer in figures 1 and 2.

Figure 1: Predicted distributions of stress types

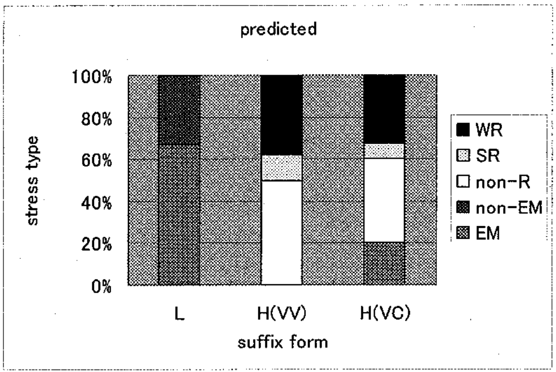
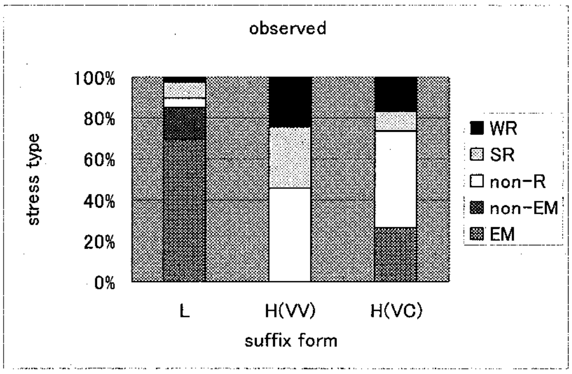


Figure 2: Observed distributions of stress types



The biggest difference between predicted and observed proportions is that there are more SR patterns than WR for H(VV), which should be the reverse according to the prediction.[4]

Statistically speaking, however, we cannot safely say that the actual proportions correspond to the predictions. The results of chi-square tests suggest that H(VC) suffixes have a pattern in which another factor might be at work. First, from the predicted proportion in (8), the following distribution is expected for 17 L suffixes, 35 H(VV) suffixes and 15 H(VC) suffixes:

(11)

	EM	non-EM	non-R	SR	WR	total
L	11.3	5.7	---	---	---	17
H(VV)	---	---	17.5	4.1	13.4	35
H(VC)	3	---	6	1.1	4.9	15

Note that we ignore the exceptional suffixes of the L type because those suffixes can be regarded as arising from other factors (see footnote 4). These expected distributions are tested against observed ones in (10). In other words, a Goodness of Fit chi-square test is independently carried out for each of the suffix type.

The results are as follows: for suffix type L, $\chi^2 = 1.28$ (with 1 *df*, p < 0.25, after Yates correction); for H(VV), $\chi^2 = 11.91$ (with 2 *df*, $p < 0.002$); and for H(VC),

[4] We also find a few unpredicted cases where L suffixes show non-retracting, Strong Retraction, and Weak Retraction patterns. This may suggest that EXTRASYLLABICITY (cf. fn.1) can be violated in marginal cases; in other words, these exceptional suffixes might be re-classified as H(VC) by syllabifying the final consonant.

$\chi^2 = 1.82$ (with 3 *df*, $p < 0.6$). The p-value of the H(VV) type strongly suggests that another factor is working for this type, while those of the others say our prediction is not bad for the L type and quite good for the H(VC) type.

In sum, we cannot conclude that the predictions made by the theory are completely borne out by the present investigation. One of the reasons for this might be that the number of suffixes is rather small compared to the number of possible rankings: in the case of suffixes with a rhyme structure L, for example, only 20 of them were found although there were 60 possible rankings. If we investigate the more 'minor' suffixes which Fudge (1984) did not include, the gap made in the present study may be filled, making the correlations closer.

Another possible reason for this unsatisfactory result is that the present investigation relies only on the data given by Fudge (1984), as mentioned above. It was not always possible to determine the stress type of several suffixes. An investigation over a larger corpus may bear on their actual stress type, altering the percentages of some cells in (10). Moreover, removing the endings whose suffixal status is dubious will have a similar effect on (10). Hopefully, a more thorough investigations will see the actual proportions draw closer to the prediction.

Alternatively, it may simply be the case that some rankings are prefered.[5] In the case of the H(VV) suffixes in (10), for example, Strong Retraction rankings might be preferred to weak ones. If this turns out to be the case, we would need some mechanism to incorporate the preference in a theory of variation within Optimality Theory. One such attempt is discussed in the next section. In any case, it is certain that a more thorough investigation is needed to draw a final conclusion, and we await such research in the future.

4. Prediction within Stochastic OT

Before concluding, let us consider the issue of stress pattern distribution in another theoretical framework, specifically, the theory known as stochastic OT (cf. Boersma, 1998, Boersma and Hayes, 2001). Essentially this theory is based on the same

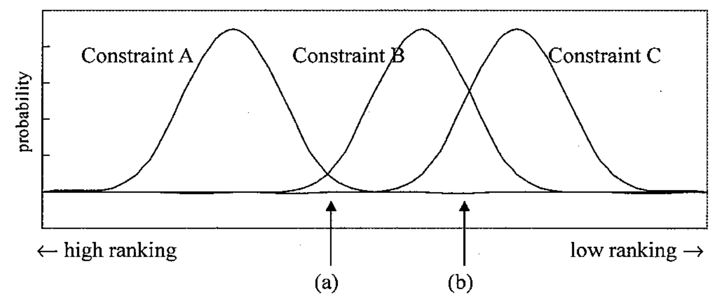
[5] Hammond (2004) tries to develop a theory which allows for such a preference.

assumptions as Partial Ordering Theory in that several constraints can be ranked freely with respect to each other, but is somewhat more flexible in that their ranking is assumed to be stochastic.

Note that the analysis of the preceding section relies heavily on the implicit assumption that each ranking has an equal chance of occurrence: between WSP and *CLASH, for example, both rankings *CLASH ≫ WSP and WSP ≫ *CLASH have an equal chance. This might not be true, however, particularly given that there are more Strong Retraction cases than predicted for suffixes with H(VV), as shown in (10). It might be the case that the ranking WSP ≫ *CLASH has a better chance of occuring than *CLASH ≫ WSP. Stochastic OT makes it possible to accomodate such probablistic differences in constraint ranking.

Constraints within this theory have a ranking value in arbitrary units. The hypothetical case in figure 3 serves as an example:

Figure 3: A sample ranking



In this case, there are more chances of ranking A ≫ B than there are of B ≫ A. The latter is only possible when a ranking value is taken from the small area designated (a). On the other hand, the ranking C ≫ B, which arises in area (b), has more chance of occurring than B ≫ A, but still less than B ≫ C.

In other words, the predictions will be the same as Partial Ranking Theory when the probability curves of the constraints overlap completely. Given the proportion in (10), the ranking values of the constraints are predicted to be quite close, but differing slightly.

In order to see how much difference the constraints have in their ranking values, a simulation was carried out with the PRAAT program. Following Apoussidou and Boersma (2004) and Apoussidou (2006), 40,000 data pieces of trisyllabic and quadrisyllabic forms were fed to the learner.[6] The input forms of the data given to the learner are as follows:

(12)

Trisyllables	Quadrisyllables	
LLL	LLLL	LHHL
HLL	HLLL	LHLH
LHL	LHLL	LLHH
LLH	LLHL	HHHL
HHL	LLLH	HHLH
HLH	HHLL	HLHH
LHH	HLHL	LHHH
HHH	HLLH	HHHH

All the logically possible output forms of foot structure are created from these inputs. Several simplifications are made, such that outputs will not contain any degenerate foot or consecutive unmetrified syllables (e.g., (H)LL<L>). The reason is that constraints prohibiting these structures are ranked higher than the five constraints under consideration here. Furthermore, no distinction between H(VV) and H(VC) is made in order to avoid too much complexity in manipulation.

The values of output distribution given to the learner were in accordance with the proportion of the stress patterns in (10). Because no distinction was made between H(VV) and H(VC), their values of non-R, SR, and WR are collapsed into one. In ambiguous cases, the values of both possibilities are accumulated. ('L L)("H) (where primary stress is on the first syllable) can be regarded as either SR or WR, for example, hence their values are added. Similarly, the value for a stress pattern is divided by the number of possibilities when multiple output forms are available. H('L L) and ("H)('L L) are both possible non-EM pattern for the input HLL, for example, hence the value of a non-EM pattern for L is evenly divided into two.

---

[6] Disyllabic forms were not included because of the simplification made in the simulation, in which no degenerate foot is created. With this simplification, no extrametrical pattern can be produced for a form with LL; e.g. *(L)<L>.

Following Apoussidou and Boersma (2004) and Apoussidou (2006), the plasticity of a reranking step is set at 0.1, evaluation noise at 2.0. The result of the simulation is as follows:

(13)

constraints	ranking values
EM	20.016
ALIGN-R	18.791
NONFIN	18.623
*CLASH	17.421
WSP	16.556

As is obvious from (13), each constraint turns out to have different values. If we look at them closely, however, we notice that each one is very close to another, suggesting considerable overlapping. It is then possible to suppose that the five constraints are ranked freely with respect to each other in overlapping areas, producing the same variation observed in previous sections. The distances in value between EM, on one hand, and *CLASH/WSP, on the other, are rather far, but this conforms to our analysis: EM is assumed to be ranked higher than *CLASH (as discussed in Zamma, 2005a), and EM and WSP do not interact to produce any phonological alternation. The fact that EM has the highest value also conforms to our analysis. Recall that only EM can be ranked higher than WSP(VC), which is ranked higher than any of the remaining four constraints (cf. Zamma, 2005a).

Of course more careful simulation is necessary through manipulation of simplified processes in the research undertaken here. It is highly likely that those adjustments will enable the predictions to be more precise. We can at least conclude that Partial Ordering Theory makes good predictions on the actual proportions of stress patterns. When there is considerable overlap between the ranking values of the constraints, the predictions are the same for the two theories, since they are based on the same basic assumption — i.e. some constraints are ranked freely with respect to each other.

5. Conclusion

The various behavior of English Class 1 suffixes is best analyzed within the framework of Partial Ordering Theory. Since it is assumed that in a given language only 'core' grammar is fixed while some parts are left unfixed, it naturally follows that phonological patterns will differ from each other due to differences in constraint rankings depending on lexical groupings.

From the list of all possible rankings, one is tempted to predict the proportion of each pattern from syllable structure. Studies on a wide number of suffixes suggest that the present analysis does a good job at predicting actual proportions, although some of them are not statistically proved. Simulation within stochastic OT shows that most constraints are ranked quite close to each other, although they do not overlap completely. A more thorough investigation of the English lexicon is necessary. At the very least, we conclude that the present approach is on the right track in accounting for both variation and distribution of stress patterns in relation to English suffixes.

Acknowledgements

I am indebted to Michinao Matsui, Donna Tatsuki and two anonymous reviewers for their valuable comments and suggestions on an earlier version of this paper. I thank Mark Campana for his suggestions on stylistic improvements. This work is supported by Grant-in-Aid for Young Scientists (B) (No. 18720131).

References

Anttila, A., 1997. Deriving variation from grammar: a study of Finnish genitives, in: Hinkens, F., van Hout, R., Wetzels, L. (Eds.), Variation, Change and Phonological Theory. John Benjamins, Amsterdam, pp. 35-68.

Anttila, A., 2002. Morphologically conditioned phonological alternations. Natural Language and Linguistic Theory 20, 1-42.

Anttila, A., Cho, Y.-M. Y., 1998. Variation and change in Optimality Theory. Lingua 104, 31-56.

Apoussidou, D., 2006. Learning to be insensitive to weight in Pintupi. Ms., University of Amsterdam [ROA: 799-0106].

Apoussidou, D., Boersma, P., 2004. Comparing two Optimality-Theoretic learning algorithms for Latin stress. Proceedings of WCCFL 23, 29-42.

Aronoff, M., 1976. Word Formation in Generative Grammar. MIT Press, Cambridge, MA.

Boersma, P., 1998. Functional phonology. Doctoral dissertation, University of

Amsterdam.

Boersma, P., Hayes, B., 2001. Empirical tests of the Gradual Learning Algorithm. Linguistic Inquiry 32, 45-86.

Chomsky, N., Halle, M., 1968. Sound Pattern of English. Harper & Row, New York.

Fudge, E., 1984. English Word-Stress. George Allen & Unwin, London.

Giegerich, H. J., 1999. Lexical Strata in English: Morphological Causes, Phonological Effects. Cambridge University Press, Cambridge.

Hammond, M., 2004. Gradience, phonotactics, and the lexicon in English phonology. International Journal of English Studies 4, 1-24.

Hayes, B., 1980. A metrical theory of stress rules. Doctoral dissertation, MIT.

Liberman, M., Prince, A., 1977. On stress and linguistic rhythm. Linguistic Inquiry 8, 249-336.

Prince, A., Smolensky, A., 1993. Optimality theory: Constraints interaction in generative grammar. Ms., Rutgers University and University of Colorado.

Selkirk, E., 1982. The Phonology of Words. MIT Press, Cambridge, MA.

Szpyra, J., 1989. The Phonology-Morphology Interface: Cycles, Levels and Words. Routledge, London.

Zamma, H., 1993. Stress retraction in English. Tsukuba English Studies 12, University of Tsukuba, pp. 21-41.

Zamma, H., 2003. Suffixes and stress/accent assignment in English and Japanese: A survey, in: Honma, T., Okazaki, M., Tabata, T., Tanaka, S., (Eds.), A New Century of Phonology and Phonological Theory. Kaitakusha, Tokyo, pp. 456-469.

Zamma, H. 2005a. Predicting varieties: Partial orderings in English stress assignment. Ms., Kobe City University of Foreign Studies and University College London. [available at Rutgers Optimality Archive: ROA-712]

Zamma, H. 2005b. Four classes in English lexicon: A solution to an old problem and a new prediction by Partial Ordering Theory. Paper presented at 13th Manchester Phonology Meeting, 26 May 2005.

Appendix

The leftmost five columns denote constraint ranking, where the further left a constraint appears, the higher it appears in the hierarchy.

The four columns in the middle read like this. If ALIGN-R has precedence over EM in a particular ranking, the leftmost column is checked, which means the ranking has a non-extrametrical property. Similarly, the second column is checked if ALIGN-R is ranked higher than NONFINALITY, suggesting a non-retracting property. The third column in the middle shows which of the three constraints — WSP, *CLASH and ALIGN-R — is ranked highest: a ranking is regarded as having a Strong Retraction property only when *CLASH is ranked highest; otherwise the ranking will produce a Weak Retraction pattern. The predicted retraction type is given in the rightmost column in the middle.

Abbreviations in seven columns on the right are as follows: A=ALIGN-R, E=EXTRAMETRICALITY, N=NONFIN, C=*CLASH, W=WSP, R=Retraction, RT=Retraction Type, WR=Weak Retraction, and SR=Strong Retraction.

						A≫E	A≫N	A, W, C	RT	L	H(VV)	H(VC)
1	ALIGN-R	EM	NONFIN	*CLASH	WSP	√	√	A	WR	non-EM	non-R	non-R
2	ALIGN-R	EM	NONFIN	WSP	*CLASH	√	√	A	WR	non-EM	non-R	non-R
3	ALIGN-R	EM	*CLASH	NONFIN	WSP	√	√	A	WR	non-EM	non-R	non-R
4	ALIGN-R	EM	*CLASH	WSP	NONFIN	√	√	A	WR	non-EM	non-R	non-R
5	ALIGN-R	EM	WSP	NONFIN	*CLASH	√	√	A	WR	non-EM	non-R	non-R
6	ALIGN-R	EM	WSP	*CLASH	NONFIN	√	√	A	WR	non-EM	non-R	non-R
7	ALIGN-R	NONFIN	EM	*CLASH	WSP	√	√	A	WR	non-EM	non-R	non-R
8	ALIGN-R	NONFIN	EM	WSP	*CLASH	√	√	A	WR	non-EM	non-R	non-R
9	ALIGN-R	NONFIN	WSP	EM	*CLASH	√	√	A	WR	non-EM	non-R	non-R
10	ALIGN-R	WSP	EM	NONFIN	*CLASH	√	√	A	WR	non-EM	non-R	non-R
11	ALIGN-R	WSP	EM	*CLASH	NONFIN	√	√	A	WR	non-EM	non-R	non-R

12	ALIGN-R	WSP	NONFIN	EM	*CLASH	√	√	A	WR	non-EM	non-R	non-R
13	EM	ALIGN-R	NONFIN	*CLASH	WSP		√	A	WR	EM	non-R	EM/non-R
14	EM	ALIGN-R	NONFIN	WSP	*CLASH		√	A	WR	EM	non-R	EM/non-R
15	EM	ALIGN-R	*CLASH	NONFIN	WSP		√	A	WR	EM	non-R	EM/non-R
16	EM	ALIGN-R	*CLASH	WSP	NONFIN		√	A	WR	EM	non-R	EM/non-R
17	EM	ALIGN-R	WSP	NONFIN	*CLASH		√	A	WR	EM	non-R	EM/non-R
18	EM	ALIGN-R	WSP	*CLASH	NONFIN		√	A	WR	EM	non-R	EM/non-R
19	EM	NONFIN	ALIGN-R	*CLASH	WSP			A	WR	EM	WR	EM/WR
20	EM	NONFIN	ALIGN-R	WSP	*CLASH			A	WR	EM	WR	EM/WR
21	EM	NONFIN	*CLASH	ALIGN-R	WSP			C	SR	EM	SR	EM/SR
22	EM	NONFIN	*CLASH	WSP	ALIGN-R			C	SR	EM	SR	EM/SR
23	EM	NONFIN	WSP	ALIGN-R	*CLASH			W	WR	EM	WR	EM/WR
24	EM	NONFIN	WSP	*CLASH	ALIGN-R			W	WR	EM	WR	EM/WR
25	EM	*CLASH	ALIGN-R	NONFIN	WSP		√	C	SR	EM	non-R	EM/non-R
26	EM	*CLASH	ALIGN-R	WSP	NONFIN		√	C	SR	EM	non-R	EM/non-R
27	EM	*CLASH	NONFIN	ALIGN-R	WSP			C	SR	EM	SR	EM/SR
28	EM	*CLASH	NONFIN	WSP	ALIGN-R			C	SR	EM	SR	EM/SR
29	EM	*CLASH	WSP	ALIGN-R	NONFIN		√	C	SR	EM	non-R	EM/non-R
30	EM	*CLASH	WSP	NONFIN	ALIGN-R			C	SR	EM	SR	EM/SR
31	EM	WSP	ALIGN-R	NONFIN	*CLASH		√	W	WR	EM	non-R	EM/non-R
32	EM	WSP	ALIGN-R	*CLASH	NONFIN		√	W	WR	EM	non-R	EM/non-R
33	EM	WSP	NONFIN	ALIGN-R	*CLASH			W	WR	EM	WR	EM/WR
34	EM	WSP	NONFIN	*CLASH	ALIGN-R			W	WR	EM	WR	EM/WR
35	EM	WSP	*CLASH	ALIGN-R	NONFIN		√	W	WR	EM	non-R	EM/non-R
36	EM	WSP	*CLASH	NONFIN	ALIGN-R			W	WR	EM	WR	EM/WR

37	NonFin	Align-R	EM	*Clash	WSP	√		A	WR	non-EM	WR	WR
38	NonFin	Align-R	EM	WSP	*Clash	√		A	WR	non-EM	WR	WR
39	NonFin	Align-R	WSP	EM	*Clash	√		A	WR	non-EM	WR	WR
40	NonFin	EM	Align-R	*Clash	WSP			A	WR	EM	WR	WR
41	NonFin	EM	Align-R	WSP	*Clash			A	WR	EM	WR	WR
42	NonFin	EM	*Clash	Align-R	WSP			C	SR	EM	SR	SR
43	NonFin	EM	*Clash	WSP	Align-R			C	SR	EM	SR	SR
44	NonFin	EM	WSP	Align-R	*Clash			W	WR	EM	WR	WR
45	NonFin	EM	WSP	*Clash	Align-R			W	WR	EM	WR	WR
46	NonFin	WSP	Align-R	EM	*Clash	√		W	WR	non-EM	WR	WR
47	NonFin	WSP	EM	Align-R	*Clash			W	WR	EM	WR	WR
48	NonFin	WSP	EM	*Clash	Align-R			W	WR	EM	WR	WR
49	WSP	Align-R	EM	NonFin	*Clash	√	√	W	WR	non-EM	non-R	non-R
50	WSP	Align-R	EM	*Clash	NonFin	√	√	W	WR	non-EM	non-R	non-R
51	WSP	Align-R	NonFin	EM	*Clash	√	√	W	WR	non-EM	non-R	non-R
52	WSP	EM	Align-R	NonFin	*Clash		√	W	WR	EM	non-R	non-R
53	WSP	EM	Align-R	*Clash	NonFin		√	W	WR	EM	non-R	non-R
54	WSP	EM	NonFin	Align-R	*Clash			W	WR	EM	WR	WR
55	WSP	EM	NonFin	*Clash	Align-R			W	WR	EM	WR	WR
56	WSP	EM	*Clash	Align-R	NonFin		√	W	WR	EM	non-R	non-R
57	WSP	EM	*Clash	NonFin	Align-R			W	WR	EM	WR	WR
58	WSP	NonFin	Align-R	EM	*Clash	√		W	WR	non-EM	WR	WR
59	WSP	NonFin	EM	Align-R	*Clash			W	WR	EM	WR	WR
60	WSP	NonFin	EM	*Clash	Align-R			W	WR	EM	WR	WR