On the Rhythm Rule in Polish

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0. OVERVIEW

We define "rhythm rules" to be phonological rules that shift weaker stresses away from stronger ones under rhythmic pressure. Both Polish and English have rules of this sort, as shown under (1):[1]

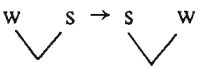
(1) a. Bógusława Bożek → Bógusława Bożek (proper name)
DDT Stácha → DDT Stácha 'Stach's DDT'

b. fourteen wómen → fourteen wómen
Mississippi múd → Mississippi múd

Rhythm rules are quite common: in recent literature one finds them proposed for French (Dell (forthcoming), Phinney (1980)), German (Kiparsky (1966)), Italian (Nespor and Vogel (1979)), Dari (Bing (1980)), Tiberian Hebrew (McCarthy (1979)), Passamaquoddy (Stowell (1979)), and Finnish (Hayes (1981)). Since not too many languages have been checked, it may turn out to be the norm, not the exception, for stress languages to have rhythm rules.

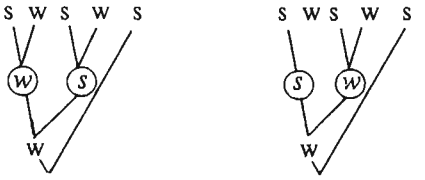
Rhythm rules are typically optional. But at least for Polish and English, the variants generated by a rhythm rule are not free, strictly speaking. Rather, the propensity to apply the rule varies, depending on the changes in rhythmic structure that the rule induces. For example, in English it would probably be the norm to apply the rule to the phrase *Mississippi législature*, but in *Mississippi legislátion* the rule would be quite unlikely to apply. Following Liberman and Prince (1977), we assume that this situation requires a twofold explanation: we distinguish the phonological operation of stress retraction from the system of rhythmic principles that determines when retraction is favored. For English, the Rhythm Rule itself can be expressed quite simply under the metrical theory of stress, as in (2):

(2) *English Rhythm Rule*



where *s* is not the strongest syllable of its phrase.

cf. Mississippi mud → Mississippi mud



To determine the propensity for stress to shift, Liberman and Prince invoke a separate representation, the *metrical grid*, which can be thought of as embodying the rhythmic structure of a text. A metrical grid is an abstract set of units arrayed in rows and columns. The height of the columns represents the stress prominence of syllables, while the rows may be viewed as series of rhythmic beats on different levels. The grids are automatically projected from metrical trees by a set of rules, the details of which may be found in Liberman and Prince (1977, 315-316, 322-323). For our purposes the following rules will suffice:

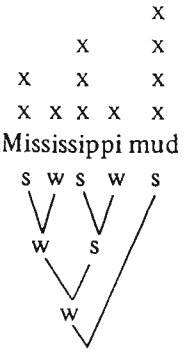
(3) *Grid Construction*

a. Give every syllable a grid mark as a place marker.

b. Referring to the metrical tree, add sufficient additional marks to the grid so that the strongest syllable of every strong constituent has a higher column than the strongest syllable of its weak sister.

Liberman and Prince further assume that certain configurations of the grid are selected as highly valued, or "eurhythmic". The variable propensity of the Rhythm Rule to apply is determined by the degree of rhythmic improvement it provides in the grid. The full story behind the application of the Rhythm Rule in (2) is that the grid of the output form (4b) is more eurhythmic than that of the input form (4a).

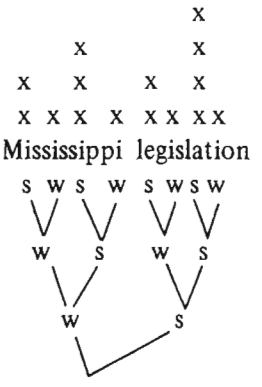
(4) a.



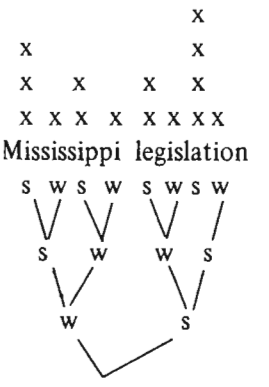
b.

The grid obtained from applying the Rhythm Rule to *Mississippi legislation*, however, is said to be no more eurhythmic than the grid of the unretracted input form, so that application of the Rhythm Rule is inhibited.

(5) a.



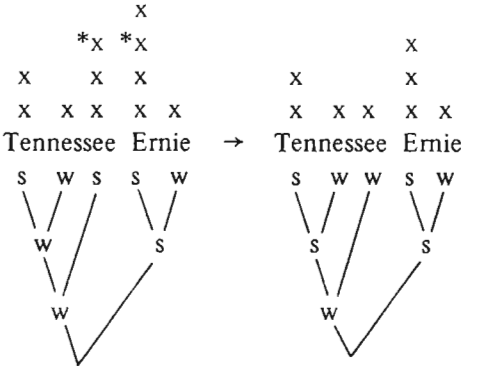
b.



Our intention is to determine explicitly what the principles are that specify when one grid is more eurhythmic than another. We will describe two proposals, that of Liberman and Prince (1977) and the proposal advanced in Hayes (1984); then use evidence from Polish to determine which theory is correct.

The problem of rhythmic tendencies in speech has occupied linguists since long before the invention of metrical theory. There have been two general approaches to the problem, which we will call the "stress clash" theory and the "rhythmic interval" theory. (For the former, see van Draat (1912), Bolinger (1965); for the latter Pike (1945), Abercrombie (1964). Bolinger (1981) would represent a mixed approach). The stress clash theory holds that the paramount goal of rhythmic phonology is to avoid adjacent stresses. Liberman and Prince advance a version of this theory which defines stress clashes as adjacent marks on any level of the grid except the lowest. An application of the Rhythm Rule that is motivated by clash reduction is shown under (6):

(6)



An apparent defect of the stress clash theory is the applicability of the Rhythm Rule to forms with no adjacent stressed syllables, as in (4), *Mississippi mud*. Liberman and Prince provide an ingenious remedy for this: they generalize the notion of "adjacent" to mean "adjacent with respect to the immediately lower level". Specifically, two grid marks constitute a stress clash if they are adjacent on a level, with no mark occurring between them on the next lower level. Under this definition, the stress shift in (4), *Mississippi mud*, can be seen to be motivated by clash reduction as well. The relevant portion of the grid is as in (7):

(7)
```
      *x   *x          x         x
   x  x    x    →     x   x     x
   Mississippi mud    Mississippi mud
```

Compare example (5), *Mississippi legislation*, which resists the Rhythm Rule because there is no clash in the relevant sense:

(8) a.
```
            x
      x     x
   x  x  x  x
   x x x x xx x x
   Mississippi legislation
```

b.
```
      x     x
   x  x  x  x
   Mississippi legislation
```

An alternative to stress clashes is the "rhythmic interval" theory. This is based on the familiar notion of stress isochrony, the principle that stresses tend to occur at regular intervals, at least in the perceptual domain.[2] In Hayes (1984), it is proposed that stress isochrony is not just a perceptual effect, but forms the basic guiding principle for the Rhythm Rule and other rules of rhythmic phonology. The propensity of the rule to apply is dependent on the degree to which the stresses of a phrase are realigned in isochronous positions. Moreover, the spacing of the stresses is not freely chosen, but appears to strive for a target interval of around four syllables. We will refer to this principle as the *Quadrisyllabic Rule*:

(9) *Quardrisyllabic Rule*
A metrical grid is eurhythmic when it contains a row of marks spaced about four syllables apart.

The greater the divergence of the actual grid intervals from the quadrisyllabic norm, the greater the dysrhythmy induced, particularly when the interval is smaller than required. Under this theory, "stress clashes" are merely the extreme on a continuum of dysrhythmy. The data noted above are explained under the rhythmic interval theory as follows: relabelling in *Tennessee Ernie* ((6)) and *Mississippi mud* ((4)) is strongly favored, as the interstress intervals are shifted from one to three and from two to four syllables, respectively. In *Mississippi legislation* ((5)), the interstress interval of the input is already the requisite four syllables, so that the Rhythm Rule is inhibited.

The evidence from Polish we invoke here will help to decide between the stress clash and rhythmic interval theories. The outline of the paper is as follows. Section 1 motivates a metrical analysis of the Polish word stress rules and the Polish Rhythm Rule. Section 2 contains data and arguments in favor of the rhythmic interval approach. In the third section, we demonstrate that the Rhythm Rule data for Polish and English are strikingly parallel in several ways, and show that the parallels are explainable on the assumption that both languages adhere to the Quadrisyllabic Rule. We conclude by considering the possibility that the Quadrisyllabic Rule is a universal of rhythmic phonology, presenting tentative data from other languages in support of this view.

1. STRESS IN POLISH

The variety of Polish described here is that of the second author, and is close to the standard of educated Poles. The basic facts of word stress in Polish are well known: in words of more than one syllable, main stress falls on the penult; and if at least two syllables precede the penult, then a secondary stress falls on the initial syllable; cf. *Warszáwa* 'Warsaw', *kìnematográfka* 'little female cinematographer'. This simple situation admits of a few complications, which we describe below.

A restricted set of words, mostly borrowed, displays antepenultimate stress in formal styles of speech. In colloquial style, the penultimate norm reasserts itself. In the words below, the "formal" stressing is given.

(10)	fízyka	'physics'
	Kórsyka	'Corsica'
	ópera	'opera'
	okólica	'surroundings'

When a word with antepenultimate stress bears a zero or disyllabic case ending, penultimate stress occurs in all styles:

(11)	a. matemátyk-a	'mathematics	(nom. sg.)'
	b. matemátyk		(gen. pl.)
	c. matematyk-ámi		(ins. pl.)
	d. matemátyk	'male mathematician	(nom. sg.)'
	e. matemátyk-a		(gen. sg)
	f. matematyk-ówi		(dat. sg.)

The account we propose for these facts essentially follows that of Dogil (1979). The principal rules of stress assignment in Polish are the Main Stress Rule and the Secondary Stress Rule, stated as follows:

(12) *Main Stress*
At the right edge of a word, form a binary foot, labelled *s w*; cf.

a. Stacha


'Stach (gen.)'

b. Warszawa

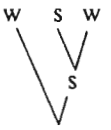

'Warsaw'

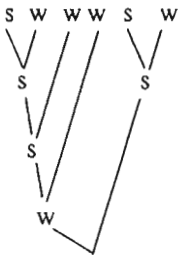
c. kinematografka


'little female cinematographer'

(13) *Secondary Stress*
Form all remaining syllables into an unbounded left-branching structure, with sister nodes labelled *sw*, and adjoin it to the main stress foot.

a. ---

b. Warszáwa


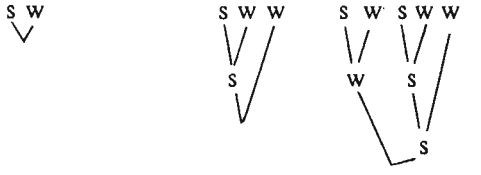
c. kìnematográfka


These rules derive the ordinary patterning of stress in most words. To account for cases of antepenultimate main stress, we follow Halle and Vergnaud (forthcoming) and Dogil (1979) in invoking a rule of extrametricality assignment. (For the theory of extrametricality rules and the evidence supporting it, see Hayes (1982).) The extrametricality rule for Polish must be something like (14):

(14) *Extrametricality*
syl → [+ex] / X ___ in formal style, where X is one of a restricted set of stems.

In the forms of (10) and (11a, e) rule (14) marks the inflectional ending *-a* as extrametrical. This syllable is thus ignored by the Main Stress Rule, so that the main stress foot is constructed over the antepenultimate and penultimate syllables. The final syllable is then adjoined to this foot by the universal convention of Stray Syllable Adjunction (cf. Liberman and Prince (1977, 294), Hayes (1982, 235)), and other rules give the correct result:

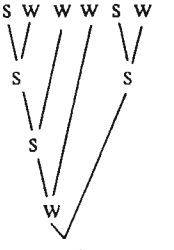
(15) [matematyk](a) → [matematyk](a) → matematyka → màtemátyka



Extrametricality | Main Stress | Stray Syllable Adjunction | other rules

In (11b), *matemátyk*, there is no post-stem syllable, so that Extrametricality cannot appiy, and penultimate stress results. In (11c), *matematyk-ámi*, Extrametricality can apply, but it runs afoul of the Peripherality Condition (Harris 1983, Hayes 1982), which requires that any extrametricality marking not at the edge of the stress assignment domain be erased. This leads to penultimate stress, as shown below:

(16)
[matematyk]ami → [matematyk](a)mi → matematykami → matematykami



input form | Extrametricality | Peripherality Condition | stress rules

There is evidence that the Peripherality Condition is universal, so we exclude it from the set of rules specific to Polish.

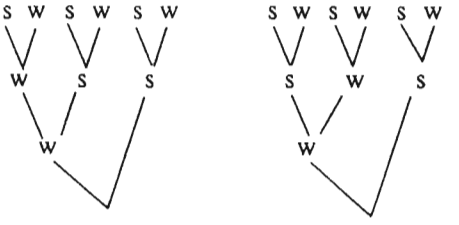
The extrametricality approach to these exceptional forms has two advantages. First, it predicts that the regular stress rule may not be violated arbitrarily, but only in cases where stress falls exactly one syllable to the left of its normal location. This pattern is a typologically common one,[3] so it is proper that it should fall out naturally from the devices of

phonological theory. Second, the theory accounts for the appearance of penultimate stress in forms with disyllabic or zero endings – if we had instead posited a stem-governed rule of antepenultimate stress, this fact would have gone unexplained.

We assume, then, the rules of Extrametricality, Main Stress, and Secondary Stress as the basic rules of word stress assignment in Polish. These rules are all word-level. They are followed by the Rhythm Rule, which applies phrasally.

The Polish Rhythm Rule is much like the English one under (2), but there are two differences. First, unlike its English counterpart, the Polish rule may shift stress in either direction. A typical case of leftward shift is shown under (17):

(17) Bógusława Bożek → Bógusława Bożek

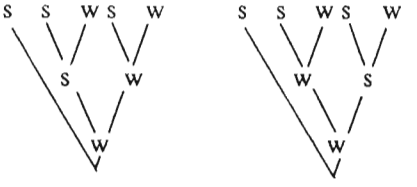


Rightward shift is much rarer, as the relevant input forms seldom arise. To our knowledge, rightward shift is found only in verb forms ending in the disyllabic clitics *-byśmy* and *-byście*.[4] The clitics are given penultimate stress at the word level, then are adjoined as weak sisters of the preceding verb, as in (18):

(18) pòszlibyśmy 'we would have left'
jèdlibyście 'you (pl.) would have eaten'

When such verb-clitic units are preceded by a stronger stress (provided, for example, by contrastive emphasis), their stress shifts rightward:

(19) mỳ pòszlibyśmy → mỳ pòszlibyśmy 'we would have left'



Mỳ pòszlibyśmy thus receives the same stress contour as *mỳ ôpuszczamy* 'we are leaving', where the verb is stressed *ôpuszczamy* in isolation.

It is clear that the rightward and leftward versions of the Polish

Rhythm Rule can be collapsed with some version of mirror image notation. One possible formulation is stated below:

(20) *Polish Rhythm Rule*

$s \rightarrow w \,/\!/\, \underset{\vee}{w} \_\_ \acute{s}$ where ś is the strongest stress of the phrase.

A second difference between the Polish and English Rhythm Rules concerns the tendency of native speakers to apply them. Although rhythmic stress shift is clearly possible in Polish (and the effects clearly audible), the propensity to apply the rule is generally less than it would be in English. For example, in a phrase like *Bogusława Bożek*, the statistical norm would be for the Rhythm Rule not to apply, whereas for a comparable English phrase like *California dreamer* the opposite holds true. In general, the Polish judgments for a given prosodic configuration are shifted relative to English in the direction of not applying the rule. The more obscure cases are still accessible to introspection, however, if they are enunciated in rhythmic speech styles, for example as accompaniment to tapping on a table. In this context, the judgments become more liberal, and approximate the tolerance of English.

2. ON THE REQUIREMENTS OF EURHYTHMY

Returning to our main issue, we wish to contrast rival views of the rhythmic goals that the Rhythm Rule strives to achieve. These are repeated below:

(21) a. *Stress Clash Theory* (Liberman and Prince (1977))
A metrical grid is eurhythmic when it contains no stress clashes. A stress clash consists of two grid marks X_1, X_2 that are adjacent on a representation consisting of their own level and the immediately lower level.

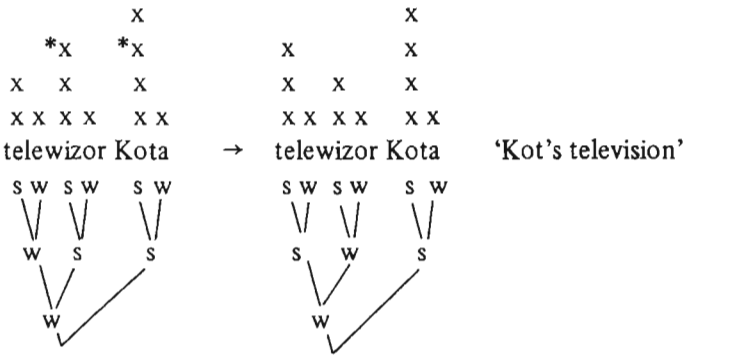
b. *Rhythmic Interval Theory* (Hayes (1984))
A metrical grid is eurhythmic when it contains a row of marks spaced as close as possible to four syllables apart (the Quadrisyllabic Rule), with greater divergence implying greater dysrhythmy.

We have located three areas in which the two theories can be tested against each other. Specifically, one may (a) vary the interstress intervals of the *input*, retaining stress clash throughout; (b) vary the interstress intervals of the *output*, again keeping the presence of clash constant; and (c) create stress clashes while keeping the interstress intervals constant. We treat these areas in turn below.

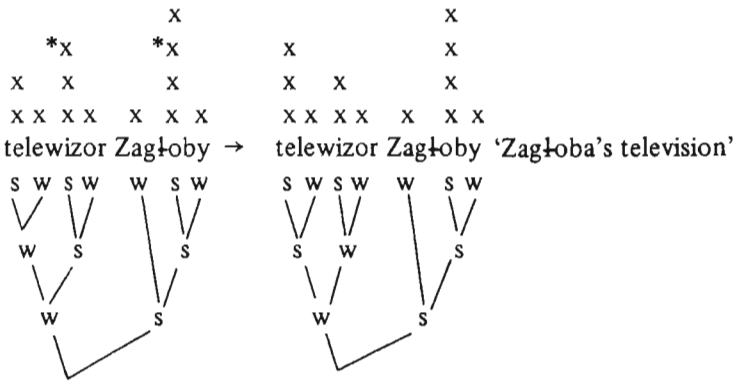
2.1 Stretching the Input Interval

Consider first the pair of examples under (22):

(22) a.



b.



By LP's definition, a clashing configuration is converted to a non-clashing one in both of these examples, so that relabelling should be equally likely in both. This is not so: it is considerably more natural to retract stress in (22a) than (22b). This difference follows directly from the rhythmic interval theory. In (22a), the best available "scansion" of the grid involves a row having marks spaced two syllables apart, while the stress-shifted version satisfies the requirement of (9) perfectly with a quadrisyllabically spaced row. By contrast, (22b) involves a shift from a trisyllabic to a pentasyllabic interval. This is no improvement, so no relabelling is expected.

Examples (22a) and (22b) are representative, as ((23)) shows:

(23) a. prẽzydẽnta ż$\dot{1}$ona — 'the president's wife'
b. ?prẽzydẽnta samóchód — 'the president's car'

b. ziẽloniũtki ptászek — 'greenish little bird'
?ziẽloniũtka ptaszyna — 'greenish little bird'

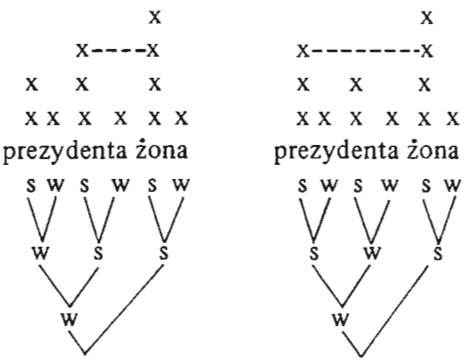
It makes no difference if the extra stressless syllable is added at the end of the first word rather than at the beginning of the second:

(24) filozofia Kota — 'Kot's philosophy'
?matematyka Kota — 'Kot's mathematics'

(N.B.: *Filozofia* is quadrisyllabic.)

These facts form part of a larger argument. The rhythmic interval theory predicts that eurhythmy should be *gradient*, with a whole range of values depending on how close the interstress intervals are to the quadrisyllabic ideal. In contrast, the stress clash theory predicts that eurhythmy judgments should fall into two categories, depending on whether a clash is alleviated or not. In (25–26), we present series of examples that can test this hypothesis.

(25) a.



'the president's wife'

b. prezydenta samochód — prezydenta samochód — 'car'

c. prezydenta fotografia — prezydenta fotografia — 'photo'

d. prezydenta telewizorek — prezydenta telewizorek — 'little television'

(26) a. Bogusława Bożek — Bogusława Bożek

b. Bogusława Zagłoba — Bogusława Zagłoba

c. Bogusława Paderewska — Bogusława Paderewska

d. Bogusława Kowalikówna — Bogusława Kowalikówna

Native judgments of the applicability of the Rhythm Rule to (25-26) indeed follow a continuum, ranging from definite plausibility on one end to clear impossibility even in rhythmic speech on the other. This follows directly under the rhythmic interval theory. In (25-26a), the interval shift is from two to four syllables, a clear improvement in eurhythmy, while in (25-26b), the shift from three to five moves the text no closer

to the target. In (25-26c,d), the Rhythm Rule actually decreases the eurthythmy of the text, by an increasing degree. Thus, the rhythmic interval theory correctly predicts continuous judgments.[5] In contrast, the stress clash theory incorrectly predicts two discrete degrees of acceptability, encompassing (25-26a,b) (in which clash is resolved) and (25-26c,d) (where the input form doesn't clash). The predicated but nonexistent boundary is illustrated below with the input grids for (25) b and c:

(25) b.

```
          x
    *x    *x
 x  x     x
x x x x x  x x
```

prezydenta samochód

c.

```
          x
    x     x
 x  x  x  x
x x x x x x x
```

prezydenta fotografia

The prediction of continuous judgments made by the rhythmic interval theory can be put to a further test: if an input form contains an interstress interval of just one syllable, this should be the most dysrhythmic of all, and the most amenable to relabelling. Polish abbreviations provide a convenient means of checking this prediction, as they regularly bear final stress-cf. *PWN* ([pèvu?én]) = *Państwowe Wydawnictwo Naukowe* 'State Scientific Publishers' or the borrowing *BMW* ([bè?emvú]). In (27), the examples under a. undergo the Rhythm Rule more readily than those under b., just as the rhythmic interval theory predicts.

(27) a. BMW^{2} Jána → B^{2}MW J^{1}ána
'Jan's BMW'

PWN^{2} zépsuł się → P^{2}WN z^{1}épsuł się
'The PWN got worse.'

b. telewizor^{2} Jána → t^{2}élewizor J^{1}ána
'Jan's television set'

saturátor^{2} zépsuł się → s^{2}áturator z^{1}épsuł się
'The soda water machine broke down.'

As before, the stress clash theory is unable to discriminate these examples. In both (27a) and (27b), the Rhythm Rule relieves a stress clash.

The examples so far have been based on the expansion of the Rhythm Rule that shifts stress leftward. But the same argument is applicable to the rightward version as well. For example, the cases under (28) show the same increasing reluctance to relabel as the interstress interval is increased in length:

(28) mý pòszlibýśmy → mý pòszlibýśmy
'*we* would have gone'

jábłka jędlibýśmy → jábłka jędlibýśmy
'we would have eaten the *apples*'

gráfikę dálibýśmy → 'gráfikę dálibýśmy
'we would have given the *graphic works*'

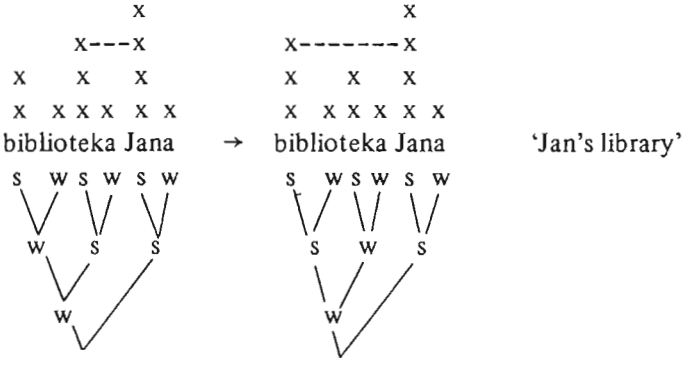
Just as before, the stress clash theory would be unable to discriminate among the data, as a clash is resolved in all cases.

In summary, the Rhythmic Interval theory correctly predicts inhibition of relabelling to the extent that the interval of the input is already close to a comfortable size – about four syllables. This gradient prediction cannot be replicated with the coarser notion of stress clash.

2.2 Stretching the Output Interval

The Rhythmic Interval theory predicts cases in which the Rhythm Rule is blocked, not because the input interval already has an appropriate size, but because the output interval is too large, being greater than the four syllable optimum. With sufficiently long words, this prediction can be tested:

(29) a.



b. télewizórek Jána → télewizórek Jána
'Jan's little television'

c. télewizoréczek Jána → télewizoréczek Jána
'Jan's little, little television'

As one goes from (29a) to (29c), the propensity to relabel decreases continuously. This is just what the Rhythmic Interval theory predicts: the output dictated by the tree structure is increased from four to six syllables, thus increasing in dysrhythmy and discouraging relabelling. The stress clash theory incorrectly predicts all of these examples to have equal status, as they all involve resolution of a clash.

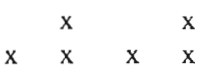
2.3. Removing Clash

In the cases described above, the rhythmic interval theory correctly distinguishes between examples that are incorrectly treated alike under the stress clash theory. We have located one case that goes the other way around, with the stress clash theory predicting a difference ignored by the rhythmic interval theory. The crucial examples are (30-31). In (30), the stress clash theory correctly predicts that the Rhythm Rule will not ordinarily apply, as the marks in boldface are not adjacent in the relevant sense (cf. the diminished grid under (30b)):

(30) a.

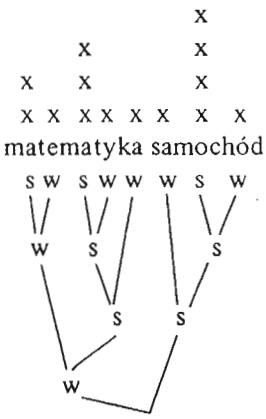
'the president's photograph'

b.



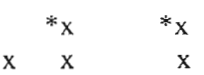
Example (31) is the same as (30) in the spacing of the principal stresses. However, it contains a stress clash, as the two main stresses are adjacent on the relevant representation:

(31) a.



'the mathematician's car'

b.



Since it contains a clash, (31) should readily undergo the Rhythm Rule by the stress clash theory. It does not; its status is essentially the same as (30). Once again, it is the rhythmic interval theory that correctly predicts the facts: both examples involve an interval shift from four to six syllables, which is no improvement in eurhythmy.

3. SUMMARY AND COMPARISON WITH ENGLISH

At this point we summarize the arguments that favor the rhythmic interval theory over the stress clash theory for Polish:

(32) a. Judgments of the applicability of the Rhythm Rule are gradient, rather than falling into two categories, and depend on interval size. This implies two things:
(i) Propensity to apply the Rhythm Rule increases as the length of the input interval decreases below four syllables.
(ii) Propensity to apply the Rhythm Rule decreases as the length of the output interval increases above four syllables.
In all cases, presence or absence of clash appears to be irrelevant.

b. If a clash is introduced by removing an "intervener" stress, while keeping the interstress interval constant, there is no increased pressure to apply the Rhythm Rule.

We take these facts to argue strongly in favor of the rhythmic interval account. Now what is remarkable about the phenomena we have discussed is that they are almost entirely reproducible in English. Example (33) shows that just as in Polish, input forms of English that clash equally but differ in interstress interval also differ in their propensity to undergo the Rhythm Rule:

(33) a.

x x----4-x x x-2-x x x x x xxx		x x----5----x x x-3----x x x x x x x x
Alabama relatives	more natural than	Alabama connections
s w s w s w w s w s w s		s w s w w s w s w s w s
b. ^{2}acrob^{3}atic f^{1}eats	more natural than	^{2}acrob^{3}atic cont^{1}ortions
c. ^{2}Mississippi ^{3}M^{1}abel	more natural than	^{2}Minne^{3}apolis ^{1}Mike

As in Polish, these examples form only part of a continuum of propensity to relabel. This can be shown by examples such as those under (34). (A useful aid to native intuitions here is to read the examples of (34) consecutively, first applying the Rhythm Rule, than not.)

(34) a. Mississippi abbreviations → Mississippi abbreviations (5 syllables)

b. Mississippi legislation → Mississippi legislation (4 syllables)

c. Mississippi connections → Mississippi connections (3 syllables)

d. Mississippi relatives → Mississippi relatives (2 syllables)

e. Tennessee relatives → Tennessee relatives (1 syllable)

Observation (32a.ii) was that as the interstress interval of the output is increased beyond four syllables, propensity to relabel diminishes. It can be replicated in English with cases such as the following.

(35) a. Alabama relatives → Alabama relatives (output 4 syllables)

b. Alamogordo relatives → Alamogordo relatives (5 syllables)

c. Apalachicola relatives → Apalachicola relatives (6 syllables)

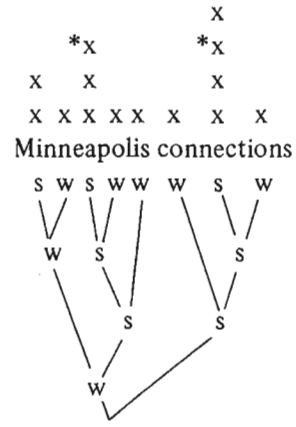
(36) a. telegraphic speech vs. telegraphic speech (4 syllables)

b. palatographic measurements vs. palatographic measurements (5 syllables)

c. onomatopoeic verse vs. onomatopoeic verse (6 syllables)

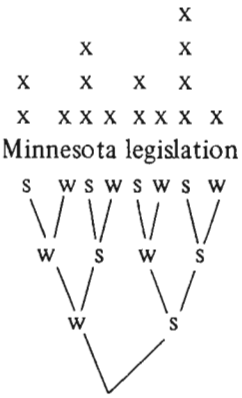
Under (32b) we observed that stress clash makes no difference when interstress spacing is held constant. This holds as well of English. For example, there is no greater propensity to apply the Rhythm Rule to (37a) than to (37b), even though (37a) contains a stress clash and (37b) does not. The examples under (38) make the same point.

(37) a.



Minneapolis connections

b.



Minnesota legislation

(38) a. hypothétical connéctions vs. sympathétic cónversátions

b. Potawótomi tradítions vs. Narragánsett occupátions

c. recreátional facílities vs. Indonésian capabílities

There are further parallels between the rhythmic behavior of Polish and English. For example, the tendency observed in Note 5 for Polish to form longer sequences into multiple quadrisyllabic intervals is shared by English. Examples like (39) are similar to Polish examples such as (i) under Note 5, while examples like (40) parallel (ii):

(39) Democrátic Apalachicóla → Démocratic Apalachicóla

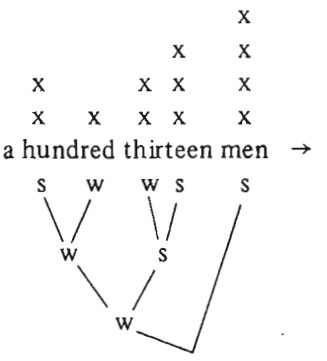
automátic onomatopóeia → aútomatic onomatopóeia

(40) twenty-séven Mississippi législators →

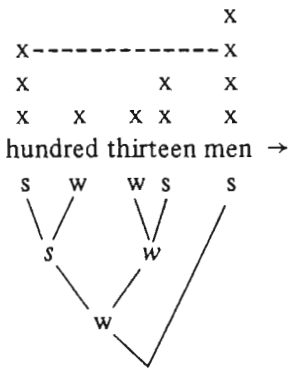
twénty-seven Mississippi législators

Another possible parallel involves an additional principle of eurhythmy. Hayes (1984) argues that the eurhythmic target involves not just a single row, but is hierarchical: if the stresses of a phrase have been arranged into quadrisyllabic intervals, then there is further rhythmic pressure to divide the quadrisyllabic intervals evenly with weaker stress beats. This "Disyllabic Rule" can account for a number of phenomena. To give just one example, the rule can explain certain double applications of the Rhythm Rule, as in (41):

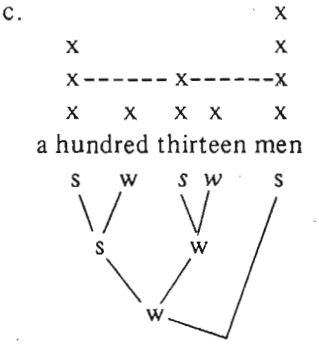
(41) a.



b.



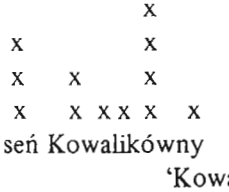
c.



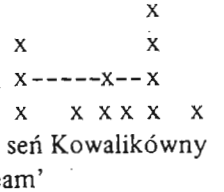
In this example, the relabelling of the phrase *hundred thirteen* satisfies the Quadrisyllabic Rule, and the subsequent relabelling of *thirteen* satisfies the Disyllabic Rule. Other arguments for the Disyllabic Rule may be found in Hayes (1984).

There is at least one aspect of Polish rhythmic phonology that appears to reflect the Disyllabic Rule. Polish words having more than one pretonic syllable normally bear an initial secondary stress–cf. *t̂elewizo̍rek* 'little television set', *K̂owalikó̍wny* 'Kowalikówna (gen.)'. However, if a word having three pretonic syllables occurs immediately after a stressed monosyllable, then the initial weak stress may optionally appear one syllable later:

(42) a.

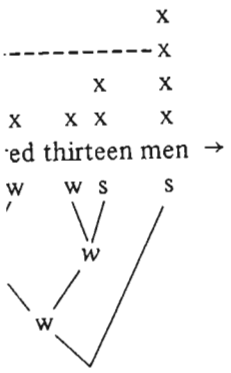


b.



'Kowalikówna's dream'

It seems plausible that the function of this stress shift is to accommodate the Disyllabic Rule.[6] The Disyllabic Rule may then be a further rhythmic principle shared by Polish and English.



4. DISCUSSION

The similarities between Polish and English rhythmic phonology observed here are noteworthy in that the prosodic systems of the two languages are otherwise quite different. Polish is impressionistically very much a syllable-timed language, with essentially fixed stress, while English is a stress-timed language, having vowel reduction, great variation in syllable durations, and an irregular, semi-free pattern of stress. While it is obviously premature to propose linguistic universals on the basis of resemblances between just two languages, we believe that such resemblances are good candidates to be checked further for universal status, especially when, as in this case, explanations based on genetic relationship or areal diffusion can be ruled out. Accordingly, we offer a conjecture for the universal basis of the English-Polish resemblance.

Recall that the Liberman/Prince program for explaining the applicability of the Rhythm Rule factors the phenomenon into two domains: (a) the phonological rule itself; (b) the rules of rhythmic evaluation, i.e. the rules that project grids from tree structure and the rules of eurhythmy. Although we have suggested a substantial revision to the latter rules, we feel that the basic division remains correct (for further argument, see Hayes (1984)). Now it is clear that Rhythm Rules may vary in their phonological form. For example, we have seen that the Polish Rhythm Rule is bidirectional, while English shifts stress only to the left, freely tolerating dysrhythmic configurations that could have been adjusted by rightward shift. The Polish Rhythm Rule also differs from the English one in a lower overall propensity to apply in any given context - although its rhythmic target is the same, it is less willing to distort basic stress contours to achieve that target. Furthermore, Rhythm Rules are not the only rules of rhythmic adjustment. Rules of destressing, length assignment, and "beat addition" also participate in achieving eurhythmic patterns (cf. Hayes (1984), Dell (forthcoming)). Thus, although the degree of interlanguage variation in the purely phonological portions of Liberman and Prince's account is surely not unlimited, the relevant rules must be stated explicitly in the grammars of individual languages, just as with other phonological rules.

We believe that for the second class of rules, the situation may be markedly different. While languages differ widely in their basic stress patterns and their rules of rhythmic adjustment, the rhythmic principles that govern these rules - i.e. the rules that project grids from trees, and the Disyllabic and Quadrisyllabic Rules - may be universal. The findings of Dauer (1983) bear on this issue in an interesting way. Dauer surveyed a rather diverse group of stress languages, testing whether they have a tendency to place stress at equal intervals. Her measurements revealed

that all the languages under investigation showed a tendency towards stress isochrony, irrespective of whether they are "stress-timed" or "syllable-timed". The interstress intervals she found correspond roughly to the target interval we posit for English. Dauer suggests that *all* stress languages may be stress-timed, and that the traditional distinction between stress timing and syllable timing reflects only the degree to which a language's phonology insists on equal syllable durations. This conclusion is in close accord with our own results: under our view, the principles that determine syllable duration – e.g. syllable canons, vowel reduction, and certain timing rules – are purely phonological, and thus are expected to be language specific to some degree. But the pressure for isochrony of stress lies in the principles of rhythmic evaluation; i.e. in the rules that project grids from trees and in the principles of eurhythmy. As we conjecture that these principles are universal, that we would expect the pressure for isochrony – and more generally, the particular *kinds* of isochrony strived for – to be independent of the phonological pattern of a language. The comparison of English and Polish is particularly striking in this regard. The two languages lie on opposite sides of the stress-timed/syllable-timed division, and differ substantially in the form of their Rhythm Rules. Nevertheless, the rhythmic principles that determine stress shift in the two languages appear to be the same.

Chomsky (1980) has argued that linguistic competence should be viewed as a separate "mental organ" – that is, as a specialized domain of the mind, whose basic representations and principles of computation have evolved independently, and are not derivable from general psychological principles. We feel that the results of current work in linguistic theory largely support this view. The domain of rhythmic phonology, however, may constitute an isolated exception. As Liberman (1979) points out, the basic principles of rhythmic evaluation at work in phonology (repetition at even intervals, and division of intervals into equal subintervals) are clearly involved in other kinds of rhythmic behavior, such as music or dance. More concretely, Woodrow (1951) has found that experimental subjects listening to series of evenly-spaced, identical sounds often impose a rhythmic structure on them that obeys the Quadrisyllabic and Disyllabic Rules. Popular traditions of versification (as opposed to art verse) often adopt binary meters with dipodic structure (cf. Attridge (1982), Burling (1966)). These are precisely the meters that obey the Quadrisyllabic and Disyllabic Rules. Facts of this nature suggest that rhythmic evaluation in phonology may be only a subcase of more general principles of rhythmic behavior. If this turns out to be the case, we will have automatically explained the bifurcation of rhythmic phonology that Liberman and Prince discovered: the rules of eurhythmy must be independent from the phonological rules, as they are not based

on linguistic principles in the first place. In addition, the study of rhythmic phonology will be seen to be a tool for developing a more powerful theory of rhythmic structure in general.

NOTES

1. In all examples, we use numbers to designate rank order of stress prominence; as will be seen below, we deny them theoretical status. The reader unfamiliar with Polish orthography should know two things. First, the letter *i* before a vowel never forms a separate syllable, but spells either a [j] glide or palatalization. Second, acute accents in Polish indicate special segmental values, not stress.
2. For some experimental confirmation of perceptual isochrony, see Donovan and Darwin (1979), Lehiste (1977).
3. Cf. Spanish (Harris (1983)) and other Romance languages, Chamorro (Chung (1982)), Buhid (Barham (1958)), and English verbs (Hayes (1982)).
4. Dogil (1979) states that in his dialect of Polish certain compounds, such as *kościół protestancki* 'Protestant church', are given falling stress, like English *élevator òperator*. In the dialect we are describing these forms don't exist, as compounds uniformly receive rising stress. However, Dogil reports (personal communication) that the results for verbal forms we describe below carry over to compounds in his speech.
5. An interesting pattern emerges when we take this process one step further, testing an interval shift from six to eight syllables. Here, the rhythmic interval theory raises the further possibility of parsing the phrase into two quadrisyllabic intervals instead of one:

(i) a.
```
                    x
      x-------x------x
      x   x   x   x   x
      x x x x x x x x x
```
prezydenta telewizoreczek 'the president's little, little television'

b. B$\overset{2}{\text{o}}$gusława Z$\overset{2}{\text{a}}$walidroż$\overset{1}{\text{a}}$nka

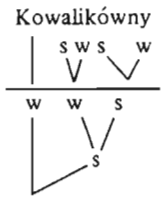
And as the theory predicts, it is indeed somewhat easier to apply the Rhythm Rule to *prezydenta telewizoreczek* and *Bogusława Zawalidrożanka* than it is to the slightly shorter forms of (25d) and (26d), *prezydenta telewizorek* and *Bogusława Kowalikówna*. In the latter forms, the trisyllabic interval following the secondary stress in the second word is too short to serve as the isochronous counterpart to a preceding quadrisyllabic interval, so that relabelling is disfavored. Double quadrisyllable intervals can also be created by multiple application of the Rhythm Rule, as in (ii):

(ii) Bogus$\overset{2}{\text{ł}}$$\overset{2}{\text{a}}$wy zielon$\overset{2}{\text{i}}$utka t$\overset{1}{\text{o}}$rba →
B$\overset{2}{\text{o}}$gusławy z$\overset{2}{\text{ie}}$loniutka t$\overset{1}{\text{o}}$rba 'Bogusława's greenish handbag'

6. It is not clear to us what specific phonological mechanism gives rise to the shift. The shift is probably related to another phenomenon, the optional appearance of multiple weak stresses in longer Polish words; for example, *telewizoreczek* 'little, little TV' may be pronounced either with one weak stress (*tèlewizoréczek*), or with two (*tèlewizoréczek*). In words with three pretonic syllables, it is at least marginally

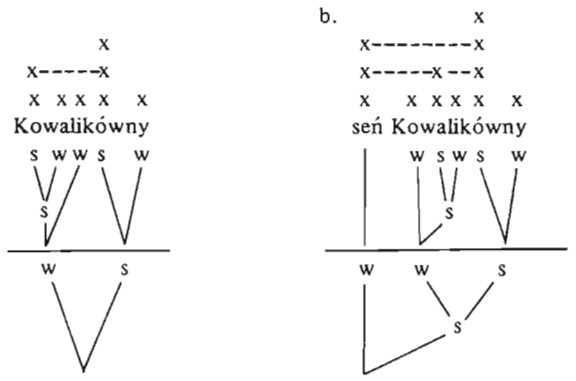
possible to place weak stresses on both the initial and the second syllables, as in *Kòwàlikówny*. Our conjecture is that stressings of this sort represent an intermediate stage of the phonological derivation. In the framework of Hayes (1981), they could be arrived at simply by applying the Main Stress Rule iteratively, thus parsing the entire word into maximally binary feet:

(i)



When the word appears in isolation, the medial foot would normally be deleted. This would largely satisfy the Quadrisyllabic Rule following the application of Stray Syllable Adjunction (cf. (iia)).

(ii)



However, if there is an immediately preceeding stressed syllable, than both the Quadrisyllabic and the Disyllabic Rules may be satisfied by deleting the initial foot, as in (iib). This account seems appealing, but we can offer it only as conjecture, as there are many other facts of tertiary word stress in Polish that are sufficiently elusive that we have not yet arrived at a satisfactory analysis of them.

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