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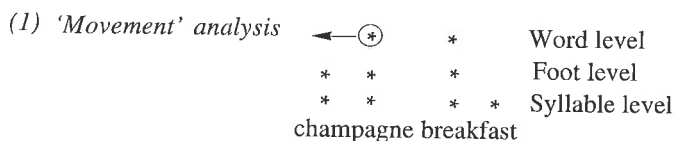
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THE PHONETICS AND PHONOLOGY OF THE RHYTHM RULE IN POST-FOCAL POSITION: DATA FROM ENGLISH

Merle Horne

INTRODUCTION

During the decade following the publication of Liberman & Prince's (1977) article proposing a metrical solution to the phenomenon of 'stress shift' or the Rhythm Rule, a number of refinements have appeared in the literature (Giegerich 1983, Prince 1983, Hayes 1984, Selkirk 1984, Gussenhoven 1991). Up until recently, however (see, though, Cooper & Eady 1986), there has been very little phonetic testing of the various theoretical accounts due mainly to their lack of phonetic claims and thus it has been difficult to evaluate the solutions. There have appeared, however, at least two phonological analyses that do in fact make predictions that can be empirically tested. These also represent two different approaches to how the stress shift data should be understood; one can be termed a 'movement' analysis and the other, a 'deletion' analysis of the Rhythm Rule. The first approach is that represented by the work of Selkirk (1984). In her grid-based metrical account, the Rhythm Rule is to be regarded as involving a movement of prominence from the lexically stressed syllable to a preceding syllable when there are two clashing word stresses. Since the theory further claims that pitch accents are already associated with main stress syllables at the point where the Rhythm Rule applies, it makes the prediction that what the Rhythm Rule involves is in fact a movement of pitch prominence from one syllable to another. Thus the derivation of '*champagne breakfast*' would, in this analysis, be represented as in (1):



The movement of the placeholder (*) on *-pagne* is conditioned by the fact that it 'clashes' with another placeholder on the same level without there being a placeholder one level down that comes between them. Since the placeholder is further associated with a pitch accent, what one can expect is that the fundamental frequency extrusion on *cham-* in *champagne breakfast* should be larger than it is in *champagne* since the pitch prominence that is underlyingly present on *-pagne* is assumed to be transferred to *cham-*.

The other analysis of the Rhythm Rule making phonetic claims is represented in work of Gussenhoven (1991). In this 'deletion' interpretation, it is assumed that what the process involves is the removal of a pitch accent on the main stress syllable of the stress shift word. Following this interpretation, the derivation of *champagne breakfast* would be represented as in the example in (2):

POST-FOCAL RHYTHM RULE: AN EXPERIMENT

A detail which has not been given much attention in analyses of the stress shift phenomenon is that concerning the phonetic correlates of the process in post-focal position where Fo cannot be assumed to play the same role in giving the impression of stress. According to Gussenhoven (1991), we do not have to "do anything" phonologically to explain it. Rather, he claims that the relatively greater prominence on *cham-* in *champagne breakfast* in post-focal position is due to the fact that the final syllable *-pagne* does not undergo as much Final Lengthening in Rhythm Rule environments as it does when the word is pronounced in phrase final position. It is this **relative** difference in duration that is assumed to be sufficient to give the impression of more prominence on *cham-*; the first syllable does not have to have a duration which is absolutely greater. Thus stress shift is ascribed to a perceptual mechanism rather than to some actual acoustic difference which would define the early syllable as acoustically more prominent.

Data

In order to test this assumption against the assumption that there could be **absolute** differences in duration we conducted an experiment using post-focal data. The test word used was *maintain* which was chosen since both of its syllables have the same rhyme constituent, making duration measurements easier to interpret. We also took the opportunity to see if the Shattuck-Hufnagel idea that the Rhythm Rule functions mainly to create a phrase initial prominence also holds in post-focal position, even though there are no pitch accents in this environment. In (3) are presented the five test sentences which were uttered as answers to questions which triggered a focal accent on MY and which made the remainder of the sentence have the status of 'Given' information and consequently be unaccented. In sentence 1, *maintain* occurs phrase initially (ϕ indicates a 'phonological phrase' boundary (Nespor & Vogel (1986)) and is followed by a word beginning with a stressed syllable; we define this environment as [+init(ial)], [+clash]. In

- 3) A: Whose book is called "Maintain Temperament"?
- [1] B: MY book is called ["Maintain Temperament"]
- * * *
* * * * *
 ϕ ϕ
- [+init
+clash]
- b) A: Whose book is called "Maintain Tenacity"?
- [2] B: MY book is called ["Maintain Tenacity"]
- * * *
* * * * *
 ϕ
- [+init
-clash]
- c) A: Whose book is called "Don't Maintain Tenements"?
- [3] B: MY book is called ["Don't Maintain Tenements"]
- * * * * *
 ϕ ϕ
- [-init
+clash]
- d) A: Whose book is called "Don't Maintain Tenacity"?
- [4] B: MY book is called ["Don't Maintain Tenacity"]
- * * * * *
* * * * *
 ϕ ϕ
- [-init
-clash]
- e) A: Whose book is called "A Temper to Maintain"?
- [5] B: MY book is called ["A Temper to Maintain"]
- * * * * *
 ϕ ϕ
- [+final]

sentence 2, *maintain* also occurs in phrase initial position but not in a clash environment as the following word begins with an unstressed syllable; we define this environment as [+init], [-clash]. Sentence 3 provides an environment where *maintain* occurs in phrase medial position but where there is nevertheless a clash; this environment is defined as [-init], [+clash]. In sentence 4 *maintain* also occurs in phrase medial position but not in a clash environment ([-init], [-clash]). Finally, in sentence 5, *maintain* occurs in phrase final position ([+final]).

Subjects

Ten speakers of Canadian English (students and staff at the University of Calgary) participated in the experiment. They were given cards containing the sentence pairs in (3) randomly presented along with six other sentence pairs which were not used in this experiment. The author read the 'A' sentences and the subjects read the 'B' sentences at a normal rate of speech. Four readings of the sentence pairs were made in quiet rooms using a cassette tape recorder. Data from two of the speakers were subsequently discarded from further analysis since, after listening to the productions of all the speakers they were judged as not having a lexical representation of the word *maintain* with the nucleus /ei/ in both syllables (i.e. /meintem/); in one set, the speaker always pronounced *maintain* with a reduced 'schwa' vowel in the first syllable ([məntem]), while the other always pronounced the word with an /i/-type vowel in both syllables (/mintin/). Disregarding these two data sets, the data from the eight remaining speakers was accepted for analysis. There were thus $8 \times 4 = 32$ tokens of each test sentence in (3) (altogether $32 \times 5 = 160$ sentences).

Analysis methods

Each occurrence of the word *maintain* was clipped out of context. The author then listened to the excised words and judged whether relatively more stress was heard on the first syllable, the second syllable, or whether both syllables seemed to have an equal level of stress. After this listening test, duration measurements of both the rhyme and the nucleus of each syllable of each token of *maintain* were made. This was done using both wave form and spectrogram displays in the CSL program package. Criteria used in segmenting were as follows: for the rhyme durations, the start point was the beginning of formant structure of the nucleus and the end point was the end of voicing in [n]. In measuring just nucleus durations, segmentation was made using the beginning and end of formant structure for the nucleus.

Results of the listener test

Results of the listener test are presented in Table 1. As can be seen, most cases of stress shift were identified in tokens of *maintain* cut from sentence 1 where the word occurred in phrase initial position (27 cases out of $32 = 84\%$) and where it was also in a clash environment. In sentence 2 where the test word occurred in phrase initial position but was not involved in a clash, 75% of the tokens were identified as having undergone stress shift. Only about half (53%) of the cases where *maintain* occurred in a non-phrase initial but clash environment were heard as having more stress on the first syllable and in cases where neither a clash was involved nor phrase initial position, only (38%) of the tokens were classified as exhibiting stress shift. In phrase final position where one would not expect the Rhythm Rule to apply if clash were a prerequisite to stress shift, more stress was in fact perceived as occurring on the final stress syllable of *maintain* in no more than 66% of the token cases for sentence 5. According to the Shattuck-Hufnagel, view, however, where clash is not a necessary trigger to stress shift, an early prominence in this environment is not unexpected if the candidate word is the only one in its phrase. Thus

the results would suggest a hierarchy of environments which trigger stress shift, where initial position takes precedence over clash and where clash takes precedence over non-clash and final position as in (4):

$$(4) \begin{bmatrix} +\text{init} \\ +\text{clash} \end{bmatrix} > \begin{bmatrix} +\text{init} \\ -\text{clash} \end{bmatrix} > \begin{bmatrix} -\text{init} \\ +\text{clash} \end{bmatrix} > \begin{bmatrix} -\text{init} \\ -\text{clash} \end{bmatrix} > \begin{bmatrix} +\text{final} \end{bmatrix}$$

		main 1:st syll. stressed	tain 2:nd syll. stressed	Equal stress on both sylls.
[1]	$\begin{bmatrix} +\text{init} \\ +\text{clash} \end{bmatrix}$	27 (84%)	0	6
[2]	$\begin{bmatrix} +\text{init} \\ -\text{clash} \end{bmatrix}$	24 (75%)	1	7
[3]	$\begin{bmatrix} -\text{init} \\ +\text{clash} \end{bmatrix}$	17 (53%)	3	12
[4]	$\begin{bmatrix} -\text{init} \\ -\text{clash} \end{bmatrix}$	12 (38%)	7	13
[5]	$\begin{bmatrix} +\text{final} \end{bmatrix}$	5	21 (66%)	6

Table 1. Results from listener test with 32 tokens of each test sentence in (3).

DURATION MEASUREMENTS

In Tables 2 and 3 are presented the duration measurements for syllable rhymes and nuclei of *maintain* where the position of stress could be identified. As can be seen, there is no evidence, neither in the rhyme measurements nor in the nucleus measurements for there being any absolute differences in duration that could be correlated with the impression of stress shift onto the first syllable of the test word in any of the cases of *maintain* in sentences 1 to 4. In sentence 5, however, where stress was heard on the second syllable of *maintain* in 66% of the tokens, there was a correlation between greater duration and more prominent stress with the stressed syllable *-tain* having a duration 1.3 times (almost 70 ms) greater than that of *main-*. Measurements of just the nucleus show somewhat more durational prominence on the pre main stress syllable of *maintain*, but the difference is on the order of 12-14 ms, a difference which probably not can be considered perceptually distinguishable given that the Standard Deviation is just as large and that the just noticeable duration difference is on the order of 10-40 ms (Lehiste 1970). The results thus lend some support to Gussenhoven's hypothesis that the effects of Final Lengthening play a role in creating the impression of stress. In phrase final position, there is no doubt that duration is a salient cue to stress on the nuclear syllable.

However, the results for the non phrase final data are not as easy to interpret in terms of Gussenhoven's predictions. Although a following accent is a trigger of the Rhythm Rule, his analysis does not claim that this accent must occur on the syllable following the lexically stressed syllable of the word subject to stress shift. Thus it does not readily explain the difference between the results for the data in sentences 1 and 3 where a clash is present in both cases but where there are 30% more cases of stress shift reported for the phrase initial tokens than the non phrase initial ones. This result is expected, however, given the Shattuck-Hufnagel hypothesis that the Rhythm Rule functions to create a phrase initial prominence. In post-focal position, however, this cannot be assumed to be an *accentual* prominence, and the question still remains, what is it then that gives the impression of relatively more prominence on a pre main stress syllable. Gussenhoven's

<u>Stress on main-</u>								<u>Stress on -tain</u>		
Sentence 1		Sentence 2		Sentence 3		Sentence 4		Sentence 5		
main-	-tain	main-	-tain	main-	-tain	main-	-tain	main-	-tain	
175	152	165	170	185	170	168	173	153	149	
182	151	173	161	183	203	159	156	161	256	
163	166	192	173	174	175	154	170	170	198	
171	164	183	184	160	162	154	160	178	226	
183	156	159	139	158	152	124	143	180	236	
163	152	166	170	134	136	134	129	183	242	
173	171	144	146	182	168	174	142	161	241	
159	186	157	161	180	167	139	138	164	254	
176	186	140	164	184	173	190	165	158	206	
160	168	158	168	158	158	152	158	147	192	
148	177	140	136	176	182	135	141	132	188	
165	160	123	139	162	173	147	147	151	248	
130	133	181	194	152	150			173	249	
120	125	171	173	137	124			142	262	
157	177	167	169	156	126			160	244	
159	162	180	174	142	140			161	251	
159	178	180	170	188	194			168	248	
150	165	183	177					160	254	
194	178	191	193					176	246	
148	167	169	168					151	202	
150	163	152	172					142	184	
193	200	158	147							
148	179	144	141							
112	133	149	131							
140	147									
152	148									
148	149									
Mean:	158.4	162.7	163.5	163.3	165.4	162.0	152.5	151.8	160.5	227.4
SD:	19.7	17.5	17.9	17.5	17.6	22.0	18.7	13.8	13.5	31.0
Ratio:	1.0/1.0		1.0/1.0		1.0/1.0		1.0/1.0		0.7/1.0	

Table 2. Rhyme durations (ms) for tokens of *maintain* where stress placement was clear. Also presented are Mean durations (ms), Standard Deviations (SD) in ms and Ratios of the duration of Syll.1/Syll.2

claim that it is not any absolute difference in duration, but rather the relative difference in duration between the phrase final environment and the non phrase final environment receives support from this experiment. Although no differences in duration were found that would allow one to say that the first syllable in *maintain* had a duration that was absolutely greater than the lexically stressed syllable in Rhythm Rule environments, it is of course true that the main stress syllable is relatively shorter in Rhythm Rule environments than it is in phrase final position. Thus by just looking at the parameter of duration, one is tempted to conclude that stress shift in post-focal position does not appear to be associated with any absolute difference in duration that would make the earlier syllable stronger than the main stress syllable.

DISCUSSION: OTHER POTENTIAL ACOUSTIC CUES TO STRESS

Although no **absolute** differences in duration were found that could be considered as correlates of stress shift in post-focal position, we feel that there are other phonetic parameters that should be examined before one can draw the conclusion that the Rhythm Rule is basically a perceptual phenomenon involving relative differences in duration between phrase final and non phrase final position. This seems to be all the more

<u>Stress on main-</u>								<u>Stress on -tain</u>		
Sentence 1		Sentence 2		Sentence 3		Sentence 4		Sentence 5		
main-	-tain	main-	-tain	main-	-tain	main-	-tain	main-	-tain	
92	87	86	83	93	92	102	94	83	105	
93	85	89	83	100	109	103	109	84	130	
93	81	98	90	97	106	100	109	80	125	
84	91	93	82	117	106	107	103	89	102	
96	103	100	88	88	77	85	79	101	117	
100	96	70	84	82	67	84	62	116	160	
102	93	88	95	102	74	96	65	102	168	
89	85	106	111	108	82	95	85	107	179	
118	108	105	112	102	70	83	75	103	150	
109	110	110	108	100	103	82	69	83	98	
99	112	87	75	113	120	83	69	79	83	
112	109	84	69	88	61	93	66	94	118	
90	58	96	127	86	69			81	132	
85	66	103	76	95	69			85	126	
98	80	113	86	96	88			92	118	
105	80	117	109	81	56			104	154	
121	92	118	91	84	63			117	149	
114	87	115	104					103	147	
123	102	107	109					115	142	
75	57	79	65					79	132	
82	73	79	59					84	112	
89	74	100	79							
86	73	100	70							
82	73	86	65							
89	55									
101	62									
98	67									
Mean:	97.2	83.7	97.0	88.3	96.0	83.1	92.8	82.1	94.3	130.8
SD:	12.6	17.0	13.1	17.8	10.5	19.6	9.1	17.6	13.0	24.5
Ratio:	1.1/1.0		1.1/1.0		1.2/1.0		1.1/1.0		0.7/1.0	

Table 3. Vowel durations (ms) for tokens of *maintain* where stress placement was clear. Also presented are Mean durations (ms), Standard Deviations (SD) in ms and Ratios of the duration of Syll.1/Syll.2

warrented when one observes differences in the non phrase final environments. The propensity for the Rhythm Rule to apply more often in phrase initial than in non phrase initial position and in clash position more often than in non clash position leads one to suspect that there is actually something in the acoustic signal that gives the impression of stress shift. If it were just the non phrase final position that triggered the impression of stress shift due to the absence of Final Lengthening, then the initial/non initial and clash/non clash environments should not make any difference as regards the occurrence of the phenomenon.

One parameter that we feel definitely influences the listener in the perception of stress in the post-focal stress shift environments is vowel quality. As is well known (Bolinger 1981), the difference between syllables with full and reduced vowels in English correlates with their stressed/unstressed status. Vowel reduction/weakening in unstressed syllables is also characteristic of other Germanic languages (cf. Koopmans-van Beinum 1980, Elert 1970). In the tokens of *maintain* in our data where stress was perceived on the first syllable, the quality of the vowel in the second syllable was heard not as a tense [eɪ] but as something like [i] or even with nasalization [ɪ̃]. Sometimes it was even difficult to perceive any clearly released nasal consonant in the syllable coda. Thus the vowel weakening (diphthong > monophthong) combined with coarticulation with the following

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