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DOWNDRIFT AND RULE ORDERING*

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This paper is concerned with the correct analysis of downdrift and the implications this has for phonological theory in general. In an examination of the analyses of downdrift proposed by Peters [1973], Fromkin [1972], and Schachter and Fromkin [1968] it is shown that the analysis proposed by Schachter and Fromkin avoids all but one of the objections which can be raised against the other two analyses. It is further shown that this final objection and thus, that the correct analysis of downdrift requires the abandonment of this assumption.

1. Introduction

Downdrift is a phenomenon found in many tone languages in which a high tone segment following a low tone segment is slightly lower in pitch than the high tone segment immediately preceding the low tone segment; the same is generally true of low tone segments following high tone segments. The phenomenon can be illustrated with the following sentence from Twi, a West African language:[1]

(1)	èyé	dùrù	s\u0300ɛ̃n	búukù	nó	'It is heavier than the book.'
	L H	L L	L	HL L	H	Distinctive tone
	3 2	4 4	4	35 5	4	Surface pitch[2]

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*I would like to thank Ian Maddieson and Tim Shopen for introducing me to some of the problems involved with downdrift as well as possible answers, and to Charles Bird, Daniel Dinnsen and Andreas Koutsoudas for reading earlier versions of this paper and making invaluable suggestions. Needless to say, all remaining faults are my own.

[1]All examples are taken from Redden, Owusu, et. al. [1963].

[2]The term 'surface pitch' is meant to be taken as a relative term, thus, the exact pitch level will depend on a great number of physical features, e.g., how long the phrase is and the pitch range of the speaker.

Many analyses of downdrift have been proposed, including those of Schachter and Fromkin [1968], Voorhoeve, Meeussen and de Blois [1969], Carrell [1970], Stewart [1971], Schadeberg [1972], and Fromkin [1972]. More recently, Peters [1973] has attacked the analysis offered by Fromkin [1972] on a number of grounds, and offered another analysis of downdrift in its place. The purpose of this paper is twofold. First, Peters' proposal will be examined and it will be shown that it has a serious problem associated with it. Second, it will be shown that out of the three problems raised by Peters against Fromkin's analysis, two are solved in the closely related solution proposed by Schachter and Fromkin [1968] and the third is an artifact of an unproven assumption concerning rule ordering. In conclusion, it will be proposed that the correct analysis of downdrift requires rules which are unordered in relation to each other.

2. Peters' Analysis of Downdrift

Both Peters [1973] and Fromkin [1972] assume that in a language with two distinctive tones, high and low, high tones are marked by the distinctive feature [+High], and low tones are marked by the distinctive feature [-High]. Peters then proposes the following rules to account for the surface downdrifted pitch levels:

(2)

R1. $[+\text{syllabic}] \rightarrow \begin{bmatrix}+\text{syllabic}\\ 0\ \text{Pi}\end{bmatrix}$

R2. $[+\text{high}] \rightarrow [1\ \text{Pi}]\ /\ \#\ \_\_\_$

R3. $[-\text{high}] \rightarrow [3\ \text{Pi}]\ /\ \#\ \_\_\_$

R4. $[+\text{high}] \rightarrow [-2\ \text{Pi}]\ /\ [-\text{high}]\ \_\_\_$

R5. $[-\text{high}] \rightarrow [3\ \text{Pi}]\ /\ [+\text{high}]\ \_\_\_$

R6. $[q\ \text{Pi}] \rightarrow [(p+q)]\ /\ [p\ \text{Pi}]\ \_\_\_$

Rule R1 introduces the feature Pi on all syllabic[3] segments; this feature is arbitrarily (according to Peters[4]) set at 0. R2 through R5

[3] Apparently the feature [+syllabic] is meant to refer to any and all tone bearing segments.

[4] Actually, this is not arbitrary, since if the original assignment of Pi was anything other than 0 it would have to be changed to 0 by a later rule for any segment not affected by R2, R3, R4, or R5. If this

then change the values of Pi in certain environments. Finally, R6 assigns the final pitches by adding the value for Pi to the value for Pi of the immediately preceding tone bearing segment. This rule is applied iteratively across the string from left to right as is predicted by the directional theory of rule application proposed by Howard [1972], that is, first the Pi of the second segment is determined by adding the value for the Pi of the second segment to that of the first segment, <u>then</u> the Pi of the third segment is determined by adding the value for the Pi of the third segment to that of the second, and so on. The application of these rules can be seen more clearly in the following derivation:

(3)

	èyé		dùrù		sɛ̃̀ñ	búùkù			nó̃
	L	H	L	L	L	H	L	L	H
R1	0	0	0	0	0	0	0	0	0
R2									
R3	3								
R4		-2				-2			-2
R5			3				3		
R6		1							
R6			4						
R6				4					
R6					4				
R6						2			
R6							5		
R6								5	
R6									3
Output	3	1	4	4	4	2	5	5	3

This, then, is Peters' analysis of downdrift. In the rest of this section, it will be shown that the feature [Pi] is problematic in this analysis and thus the analysis must be rejected.

The examination of [Pi] will first deal with what its physical correlates are. Rules R2, R3 and R6 actually assign pitch values, that is, integers which correspond with the actual fundamental frequency of

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were not the case, two immediately adjacent segments with the same tone would not be assigned the same pitch.

the segment in question.[5] Thus, in acoustic terms, the physical correlate for [Pi] in these cases could be considered to be 'fundamental frequency' where 1 stands for the highest fundamental frequency and higher numbers stands for lower fundamental frequencies. [Pi] in rules R1, R4, and R5, however, does not refer to the actual pitch value of the segment in question. This is immediately obvious for R1 and R4 in that although the segment with the highest pitch supposedly receives an integer value of 1, these two rules assign integer values of 0 and -2, respectively. If [Pi] in these rules did refer to fundamental frequency, they would be assigning frequencies 'higher' than the 'highest possible' frequency. Indeed, that Peters does not intend these three rules (R1, R4, R5) to refer to pitch value, or fundamental frequency, is obvious when the descriptions of these rules as given by Peters are examined. By R1

> "...all syllables are...assigned a pitch increment of 0." (p. 149, emphasis mine)

Then, by rules R4 and R5

> "...the pitch increments are reassigned wherever there is a step up or down..." (p. 150, emphasis mine)

Finally, [Pi] is used in both senses in R6, as can be seen in Peters' prose statement of the rule:

> "Finally, pitch values are computed from left to right across the phrase by adding each pitch increment to the pitch value of the preceding syllable." (p. 150, emphasis mine)

The feature [Pi] in these rules, then, represents the difference in pitch, or fundamental frequency, between the segment in question and the immediately preceding segment, that is, it relates the pitches of these two segments.

This claim makes the feature [Pi] as used in R1, R4, R5, and in places in R6 different from all other generally accepted phonological features. While these other phonological features all have some physical correlates, be it acoustic, articulatory, or perceptual, [Pi] in these instances

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[5] Like 'surface pitch' (fn. 2) 'actual fundamental frequency' is meant as a relative term, subject to physical features.

does not. For this reason this use of [Pi] is highly suspect, for it adds an entirely new type of distinctive feature to phonological theory on the basis of only one set of observations.[6]

Even if this objection could be met, [Pi] in R2, R3, and part of R6 definitely represents something entirely different than it does in R1, R4, R5 and the rest of R6. This fact forces us to reformulate the rules proposed by Peters in order to avoid the unsupported claim that a given feature can represent different things in different rules. This can be done by using the feature [Pi] to represent only the relational feature [Pitch increment] and [Pv] to represent the feature [Pitch value]. With this distinction made, the following rules are obtained:

(4)

R1'.	[+syllabic]	→	$\begin{bmatrix}\text{+syllabic}\\ \text{0 Pi}\end{bmatrix}$	
R2'.	[+high]	→	[1 Pv]	/ # ___
R3'.	[-high]	→	[3 Pv]	/ # ___
R4'.	[+high]	→	[-2 Pi]	/ [-high] ___
R5'.	[-high]	→	[3 Pi]	/ [+high] ___
R6'.	[q Pi]	→	[(q+p) Pv]	/ [p Pv] ___

However, given this formulation of the rules the feature [Pi] as it has been more exactly defined is further suspect as can be shown in the following derivation:

(5)

	è-	yé	dù-	rù	sɛ̃̀ñ	bú-	ù-	kù	nṍ
	L	H	L	L	L	H	L	L	H
R1'	OPi	OPi	OPi	OPi	OPi	OPi	OPi	OPi	OPi
R2'									
R3'	3Pv								
R4'		-2Pi				-2Pi			-2Pi
R5'			3Pi				3Pi		
result of R6'	[OPi 3Pv]	[-2Pi 1Pv]	[3Pi 4Pv]	[OPi 4Pv]	[OPi 4Pv]	[-2Pi 2Pv]	[3Pi 5Pv]	[OPi 5Pv]	[-2Pi 3Pv]

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[6] Even Foley [e.g., 1970], who claims that phonological features do not need to have physical correlates, essentially sets up hierarchies of physical segments.

The first problem is that having the first syllable specified as [OPi] is either false or meaningless depending on whether or not the phrase it is in follows another phrase. In the case where its phrase does follow another phrase it is false since the pitch of the first syllable in a phrase is not generally the same as the pitch of the final syllable in the preceding phrase; indeed, the two pitches are not systematically related in any way. On the other hand, in the case where its phrase does not follow another phrase it is meaningless since there is no preceding syllable to which the feature [OPi] can refer. These difficulties could formally be avoided by complicating R1 so as not to assign the feature [OPi] to the initial segment in a phrase. However, as this complication is completely _ad hoc_, proposed only to avoid the problems mentioned above, it does not really save the analysis.

The second problem with the newly defined feature [Pi] is that it is completely redundant on the surface in all syllables other than the first one in a phrase. This stems from the fact that the values for [Pv] are necessary on the surface to determine the actual pitch of the segment in question and that given the pitch values for any string of syllables it is possible to determine unambiguously the pitch increments for all syllables excepting the first.

In conclusion, it has been shown in this section that the feature [Pi] as used by Peters is extremely suspect. Since this analysis depends crucially on the acceptance of this feature, it appears the analysis should be rejected.

3. Towards a More Adequate Analysis of Downdrift

In this section it will be proposed that there is already an analysis of downdrift which, if not entirely correct, is very close to being correct. This is the analysis proposed by Schachter and Fromkin [1968]. In addition, in the next section it will be proposed that such an analysis requires the abandonment of the assumption that all rules are linearly ordered. Thus, this analysis has definite implications for phonological theory concerning the application of rules.

Before examining the analysis of Schachter and Fromkin [1968], however, we will examine the closely related analysis of Fromkin [1972] and Peters' objections to it as this will afford us a way of evaluating Schachter and Fromkin's analysis more easily. Fromkin's analysis consists of the following two rules:[7]

(6) R7. a. [+high] → [p 1]

b. [-high] → [p 3]

R8. RL: [αhigh] → [αhigh, p<+1>] / [αhigh, p]< $[-\alpha\text{high}]_1$> ___

R8 is a conflation of the following four rules:

(7) R8. a. [+high] → [+high, p+1] / [+high, p] $[-\text{high}]_1$ ___

b. [+high] → [+high, p] / [+high, p] ___

c. [-high] → [-high, p+1] / [-high, p] $[+\text{high}]_1$ ___

d. [-high] → [-high, p] / [-high, p] ___

The notation 'RL' at the beginning of R8 in (6) indicates this is a Right Linear Rule (Johnson [1970]), applying iteratively across the string from left to right. The operation of these rules can be seen in the following derivation from Twi:

(8)

	èyé		dùrù		sɛ̀ñ	búùkù		nṍ
	L	H	L	L	L	HL	L	H
R7a		1				1		1
R7b	3		3	3	3	3	3	
R8c			4					
R8d				4				
R8d					4			
R8a						2		
R8c						5		
R8d							5	
R8a								3
Output	3	1	4	4	4	25	5	3

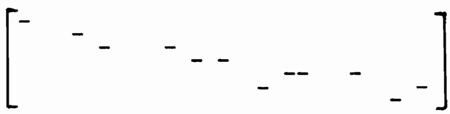
Peters attempts to demonstrate that Fromkin's analysis is problematic in at least three areas: 1) it makes certain empirically incor-

[7] R8 is not the final rule given by Fromkin but just the part which deals with downdrift. The final rule, which also attempts to account for downstep, will be discussed below.

rect predictions, 2) it is 'notationally extravagant', and 3) it makes use of an unjustified 'syllabic cycle'. Peters notes cases of empirically incorrect predictions both with regard to downstep and to the size of pitch intervals between a high tone and a low tone.

Downstep is the phenomenon by which a high tone is slightly lower in pitch than an immediately preceding high tone but where there is no independent motivation to posit an intervening low tone to 'trigger' this lowering. This phenomenon can be illustrated by the following sentence from Twi (' indicates a downstepped tone):

(9)	mẽ́	se̍kã̍n	fófo̍ró	kɛ̀séɛ́	nṍ	ñ̀yɛ́	'My other big knife is no good.'
	H	D D	H D H	L HH	H	L H	
	1	2 3	3 4 4	6 55	5	7 6	



To account for downstep, Fromkin marks all 'downstepped' tones [+high, +mid] and adds the following rule to those given in (7) as R8 a-d:

(10) R8. e. $[+high] \rightarrow [+high,\ p{+}1]\ /\ [+high,\ p] \begin{bmatrix} \underline{\quad} \\ +mid \end{bmatrix}$ [8]

This can then be conflated with R8a-d to give R8':

(11) R8'. RL:

$$[\alpha high] \rightarrow [\alpha high,\ p\langle{+}1\rangle_{1,2}]/[\alpha high,\ p]\langle[-\alpha high]_1\rangle_2 \begin{bmatrix} \underline{\quad} \\ \langle +mid\rangle_1 \end{bmatrix}$$ [9]

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[8] The rule actually given by Fromkin is:

$$[+high] \rightarrow [+high,\ p{+}1]\ /\ \begin{bmatrix} +high \\ -mid \end{bmatrix} \begin{bmatrix} \underline{\quad} \\ +mid \end{bmatrix}$$

However, this formulation would not apply to a downstepped tone following a downstepped tone, so that the second downstepped tone in such a sequence would be assigned a pitch by R8b and thus be on the same pitch level as the immediately preceding downstepped tone instead of one step below it. This problem can be eliminated by removing the [-mid] specification on the first high tone.

[9] This conflation actually contains one other subrule, R8f:

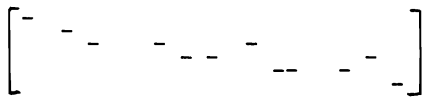
$$\text{R8f.}\quad [-high] \rightarrow [-high,\ p{+}1]\ /\ [-high,\ p] \begin{bmatrix} \underline{\quad} \\ +mid \end{bmatrix}$$

However, as no segment can ever be marked [-high, +mid], this expansion can by definition never apply.

However, when this rule is applied to the sentence in (9) the following derivation is obtained:

(12)

	mẽ́	se̍	kã̍n	fó	fo̍	ró	kɛ̀	séɛ́	nṍ	ǹ	yɛ́
	H	D	D	H	D	H	L	HH	H	L	H
R7a	1	1	1	1	1	1		11	1		1
R7b							3			3	
R8e		2									
R8e			3								
R8b				3							
R8e					4						
R8b						4					
R8a								5			
R8b								5			
R8b									5		
R8c										4	
R8a											6
Output	1	2	3	3	4	4	3	55	5	4	6



According to these rules, the final low tone in the sentence is higher than either the high tone immediately preceding or following it! As was noted by Peters, this problem arises because

> "...the Downdrift rule (6) [R8' in (11) - JMC] assigns pitch to a Low tone immediately following a sequence of [+Hi] tones by referring only to the pitch of the last overt Low tone, without regard to how many covert Low tones (in the form of Drop [that is, downstepped - JMC] tones) might be intervening..." (p. 146)

That is, although downstepped 'act' as though they are immediately preceded by a low tone (in that they are slightly lower than the immediately preceding high tone) this 'low tone' never appears. Thus, when a low tone following a downstepped tone is assigned a pitch value, this other 'low tone' is not taken into account. One possible solution to this problem, noted both by Fromkin and Peters, would be to posit a low tone before each surface downstepped tone. This low tone could trigger the lowering and would then be deleted. However, this possibility is rejected by both, primarily on the basis that it would violate

Kiparsky's [1968, 1971] constraint against 'absolute neutralization'.[10]

The second area in which Fromkin's analysis makes empirically incorrect predictions concerns the size of the pitch intervals from high to low and vice versa.[11] To see this, (13) can be compared with (8).

(13) mɛ́kɔ̀ hɔ́ 'I will go there.'

	H	L	H
R7a	1		1
R7b		3	
R8a			2
Output	1	3	2
	[‾	_	‾]

The interval from a high tone to a low tone is three in (8) where the initial segment is a low tone while it is only two in (13) where the initial segment is a high tone. Likewise, the interval from a low tune to a high tone is two in (8) but only one in (13). In other words, this analysis claims that pitch intervals are less when the initial segment is a high tone than when it is a low tone. Unless it can be shown

[10] This rationale, however, would not hold if the analysis of downstep discussed in Clifton [1975] is correct. In this article it is argued that phonological theory needs to refer to 'nonsegmental tones', that is matrices which are marked [-segmental, ±high]. These matrices interact with other tone bearing segments but, like boundaries which are also nonsegmental, have no surface realization themselves. This seems to be what Schachter and Fromkin [1968] have in mind when they talk about the Habitual low tone morpheme, which consists of a low tone which, for example, can trigger downdrift, but never has any direct surface representation. Like boundaries, these matrices do not have to be deleted by rule to escape having a surface representation, instead, the feature [-segmental] ensures this. Thus, they are no more subject to Kiparsky's constraint against absolute neutralization than are boundaries. Because of this, it would be possible to posit a nonsegmental low tone before any surface downstepped high tone which would trigger downdrift, not have to be deleted, not have any surface representation, and not be objected to because of absolute neutralization.

[11] I had also noted this failure of Fromkin's analysis, as was reported in Maddieson, Shopen and Okello [1973].

that this is indeed the case, Fromkin's analysis must be modified so that the size of the pitch intervals does not depend on the tone of the initial segment.[12] This can be done by changing R7 in (6) in either of the following two ways:

(14) R7'. a. [+high] → [p 1] / #

b. [+high] → [p 2] / $[\overline{\text{-high}}]$ ___

c. [-high] → [p 3]

R7''.a. [+high] → [p 1]

b. [-high] → [p 3] / #

c. [-high] → [p 4] / $[\overline{\text{+high}}]$ ___

However, there are two objections against such a reanalysis. First, we are faced with a completely arbitrary decision as to which of the two reformulations of PA is correct. Second, and more important, is that given either reformulation we are forced to complicate the grammar, claiming that pitch is assigned differently to high tones as opposed to low tones, with no concommitant increase in explanatory power.

The second objection advanced by Peters against Fromkin's analysis is that:

> "This rule (6) [R8' in (11) -JMC] is notationally extravagant, using some of the most powerful devices of generative phonology, such as the sub-one notation to indicate one or more segments of a specified kind (e.g. $[\text{-Hi}]_1$), as well as indexed angle brackets which are costly at the least and of questionable validity in general." (pp. 147-8)

This objection is not especially convincing as nowhere does Peters even attempt to give any justification for claiming that these notations are 'extravagant'. It is not even clear as to whether Peters simply wants to make the use of these notations more costly in some unspecified way, or to eliminate them from phonological theory completely.

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[12] This seems to have been the assumption in all previous studies of downdrift. It is clear that in none, not even Fromkin's analysis, is the claim explicitly made that the size of the intervals depends in any way on the tone of the first segment in the phrase.

However, as will now be shown, both this 'problem' and the problem of empirically incorrect predictions are resolved by the closely related analysis of Schachter and Fromkin [1968].

The analysis of downdrift proposed by Schachter and Fromkin [1968] can be formalized in terms of the following rules:[13]

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(15)   R9.   a.  [+high] → [Pv 1] / [+phrase boundary] ___
             b.  [-high] → [Pv 3] / [+phrase boundary] ___
       R10.  a.  [+high] → [Pv n-2] / [-high, Pv n] ___
             b.  [-high] → [Pv n+3] / [+high, Pv n] ___
             c.  [+high] → [Pv n] / [+high, Pv n] ___
             d.  [-high] → [Pv n] / [-high, Pv n]
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The operation of these rules can be seen in the following derivations using the sentences used to illustrate Fromkin's analysis in (8) and (13) respectively:

```
(16)           èyé dùrù sɛ̀ñ bʊ́ùkù nɔ̃́
               L H  L L  L   HL L  H
     R9b       3
     R10a        1
     R10b           4
     R10d             4
     R10d                4
     R10a                    2
     R10b                     5
     R10d                       5
     R10a                          3
   Output      3 1  4 4  4   25 5  3
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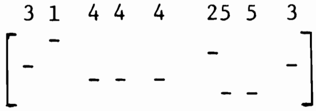

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[13] As Schachter and Fromkin use their own set of conventions for formulating these rules, those presented here are essentially 'translations' into the conventions proposed by Chomsky and Halle [1968].

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(17)            mɛ́kɔ̀ hɔ́

                 H L  H

       R9a       1
       R10b        4
       R10a           2

    Output       1 4  2
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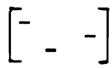

This analysis can be expanded to account for downstep also by marking downstepped tones [+mid] as they are in Fromkin's analysis and adding the following subrule to rule 10 in (15):[14]

(18) 10.e. [+mid] → [Pv n+1] / [+high, Pv n] ___

The operation of this subrule can be seen in the following derivation using the sentence used to illustrate Fromkin's analysis in (12):

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(19)           mẽ́ sꜜekꜜãn fófꜜoró kɛ̀séɛ́ nṍ ñ̀yɛ́

                H  D D   H D H  L HH  H L H

       R9a      1
       R10e        2
       R10e          3
       R10c              3
       R10e                4
       R10c                  4
       R10b                     7
       R10a                       5
       R10c                        5
       R10c                           5
       R10b                             8
       R10a                               6

    Output      1  2 3   3 4 4  7 55  5 8 6
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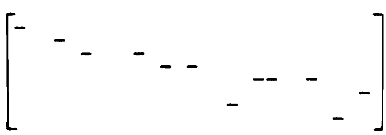

As has already been mentioned, the analyses of Fromkin [1972] and

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[14] This rule is entirely my own, since Schachter and Fromkin do not try to account for downstep by marking downstepped tones [+mid].

Schachter and Fromkin [1968] are very similar. The main difference is that while in Fromkin's analysis the immediately preceding tone with the same coefficient for the feature high is referred to when pitch is assigned, in Schachter and Fromkin's analysis the immediately preceding tone is referred to regardless of its coefficient for the feature [high]. However, as can be seen from examining (16), (17) and (19), this difference resolves the problems Peters advances against Fromkin's analysis. As can be seen in (19), low tones following downstepped tones are given the correct pitches. Furthermore, the pitch interval from a high tone to a low tone is always three while that from a low tone to a high tone is always two, regardless of the tone of the first tone bearing segment in the phrase. It is also the case that none of the notations found to be objectionable by Peters are needed in this analysis.[15] It should also be pointed out that the objections advanced in the first section of this paper against the analysis proposed by Peters do not apply to either the analysis proposed by Fromkin or that proposed by Schachter and Fromkin. In each of these analyses the p (in Fromkin's) or Pv(in my formalization in (15) of Schachter and Fromkin) represent one thing only, fundamental frequency. Thus, they are like other features given by Chomsky and Halle [1968], especially a feature like stress.

4. Downdrift and Rule Ordering

In the preceding section we discussed the first two objections Peters raises against the analysis of downdrift proposed by Fromkin and showed that the analysis proposed by Schachter and Fromkin did not encounter similar objections. In this section we will examine Peters' third objection against Fromkin's analysis. In doing this,

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[15] R10c and R10d in (15) could be collapsed by variables as follows:

$$[\alpha\text{high}] \rightarrow [\text{Pv } n] \;/\; [\alpha\text{high}, \text{Pv } n] \;\_\_\_$$

However, if any objections are raised against variables, they are not required as can be seen from the fact that the rules are formulated without them.

we will attempt to demonstrate that although this objection can also be raised against Schachter and Fromkin's analysis, it arises from an unproven assumption concerning the ordering of phonological rules. Thus, we will suggest that a correct analysis of downdrift requires that the rules for downdrift be unordered in relation to each other.

The third objection raised by Peters is as follows:

> "...each of the six sub-rules [of R8' in (11) - JMC] must be tried on the first syllable until a sub-rule is found that will apply to the tone of that syllable or until all six sub-rules have been unsuccessfully tried on that syllable. Then, and only then, does the focus of the application move to the second syllable, where again all the sub-rules are tried until one is found that will apply. Any other mode of application will give the wrong results... Thus, in effect, this one "schema" constitutes a <u>cycle</u> of rules that is to be applied syllable by syllable from left to right." (p. 148, Peters' emphasis)

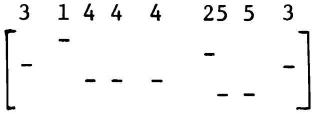
Peters then goes on to note concerning this "cycle" that

> "(t)he little evidence that has been advanced to support such a mode of rule application (Anderson [1968]) has been tellingly argued against by Johnson [1970:92-118]." (p. 148)

Although this is not noted by Peters, upon further examination it becomes apparent that the reason Peters seems compelled to appeal to a syllabic cycle to ensure proper application of R8' is that without it an ordering paradox ensues. This paradox can be shown by referring back to (8) (reproduced as (20) for reference).

(20) èyé dùrù sɛ̃̀ñ búùkù nṍ

	L	H	L	L	L	HL	L	H
R7a		1				1		1
R7b	3		3	3		3	3	
R8c			4					
R8d				4				
R8d					4			
R8a						2		
R8c						5		
R8d							5	
R8a								3
Output	3	1	4	4	4	25	5	3



In this derivation R8c must apply both before and after R8d and R8a. Likewise, R8a must apply both before and after R8c and R8d, and R8d must apply both before and after R8a and R8c. The same type of ordering paradox can be found in the analysis proposed by Schachter and Fromkin as can be seen from (16) (reproduced here as (21) for reference).

```
(21)              èyé dùrù sɛ̃̀ñ búùkù nṍ

                  L H  L L  L   HL L  H

         R9b      3
         R10a       1
         R10b          4
         R10d            4
         R10d               4
         R10a                   2
         R10b                    5
         R10d                      5
         R10a                         3

      Output      3 1  4 4  4   25 5  3
                 [  -                  ]
                 [-             -     -]
                 [     - -  -          ]
                 [               - -   ]
```

The syllabic cycle, then, is proposed to avoid such a paradox. This cycle can be characterized by a series of bracketings, the innermost pair being around the first syllable, the next pair around the first two syllables, the third pair around the first three syllables, and so on. According to this characterization, the sentence used in (20) and (21) would be bracketed as follows:

(22) [[[[[[[[[è]yé]dù]rù]sẽ̀ñ]bú]ù]kù]nṍ]

Given such bracketing, only one rule will be able to apply nonvacuously on each cycle,[16] since there is only one tone bearing segment in each cycle which will not have been assigned a pitch in an earlier cycle. Thus, the ordering of the rules is no longer at issue. However, as Peters notes, this solution is not a pleasant one since there does not seem to be any independent motivation for such a syllabic cycle. Thus,

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[16]If vacuous application was not prohibited, the disjunctivity associated with both variables and angle brackets would block the proper application of rules in certain instances.

if Peters is correct in stating that "(a)ny other mode of application will give the wrong results", Schachter and Fromkin's analysis must be abandoned.

The claim that a syllabic cycle is required to ensure the proper application of R8' and R10 is, however, based on the assumption that rules must be linearly ordered, that is, that if a rule A precedes rule B in one point in any given derivation within the same cycle it must also precede rule B at any other point in that derivation or in any other derivation in any given cycle. This assumption, however, is being increasingly questioned, in part at least, because of cases like this where a given rule seems to need to apply both before and after another rule within one cycle. Furthermore, cases in which it has been claimed that rules cannot be linearly ordered have been found in both phonology and syntax. In syntax, for example, we find Fauconnier's [1971] analysis of agreement in French, Hastings' [1973] analysis of several pairs of rules in English, and Hudson's [1975] analysis of Conjunction Reduction, while in phonology we find Anderson's [1969] theory of local ordering, Dinnsen's [1974] analysis of glide formation in Spanish, and Escure's [1974] analysis of vowel lengthening in French.

If, then, we assume like Koutsoudas, Sanders and Noll [1974] that rules cannot be linearly ordered but apply instead whenever their structural descriptions are met unless a universal principle predicts otherwise, and, like Ringen [1973], that one of these principles is that a rule cannot apply vacuously, Schachter and Fromkin's analysis will apply properly.[17] For example, given the underlying form

èyé dùrù sɛ̀̃ñ búùkù nɔ̃́

L H L L L HL L H

the only rule which can apply is R9b. After this applies, we obtain

---

[17] For the proper application of R10e, the rule accounting for downstep, we also have to assume Proper Inclusion Precedence (Koutsoudas, Sanders and Noll [1974]). This is because for any tone marked [+mid], two rules, R10c and R10e could potentially apply. For example, given

èyé dùrù sɛ̃̀ñ búùkù nṍ
L H L L L HL L H
3

to which only R10a can apply nonvacuously. After this applies, we obtain

èyé dùrù sɛ̃̀ñ búùkù nṍ
L H L L L HL L H
3 1

to which only R10b can apply nonvacuously, yielding

èyé dùrù sɛ̃̀ñ búùkù nṍ
L H L L L HL L H
3 1 4

to which only R10d can apply nonvacuously, yielding

èyé dùrù sɛ̃̀ñ búùkù nṍ.
L H L L L HL L H
3 1 4 4

Only R10d can apply nonvacuously at this point, and so it does even though it has already applied, yielding

èyé dùrù sɛ̃̀ñ búùkù nṍ.
L H L L L HL L H
3 1 4 4 4

Now only R10a can apply nonvacuously, so it is applied even though it

---

the sequence

$$\begin{bmatrix} \text{+high} \\ \text{Pv } n \end{bmatrix} \quad \begin{bmatrix} \text{+high} \\ \text{+mid} \end{bmatrix}$$

where we are assigning pitch to the second segment, R10c could apply assigning a pitch of <u>n</u>, and R10e could apply assigning a pitch of <u>n+1</u>. Since R10c could potentially apply in all instances where R10e could apply and in others, Proper Inclusion Precedence correctly predicts R10e will apply and not R10c.

applied before R10c, yielding

èyé dùrù sɛ̀ñ búùkù nő.

L H L L L HL L H

3 1 4 4 4 2

This process continues until there are no rules which can apply non-vacuously to the input string. At this point the derivation ends. Thus, downdrift seems to be one more case where rules need to apply in an unordered fashion. If this is indeed the case, this is simply one more nail in the assumption of linearly ordered rules' coffin.

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