

CONTEXTUAL LABIALIZATION IN NAWURI*

Roderic F. Casali
Ghana Institute of Linguistics
Literacy and Bible Translation
and UCLA

A spectrographic investigation into the non-contrastive labialization of consonants before round vowels in Nawuri (a Kwa language of Ghana) supports the notion that this labialization is the result of a phonological, feature-spreading rule and not simply an automatic transitional process. This assumption is further warranted in that it allows for a more natural treatment of some other phonological processes in the language. The fact that labialization before round vowels is generally not very audible is explained in terms of a principle of speech perception. A final topic addressed is the question of why (both in Nawuri and apparently in a number of other Ghanaian languages as well) contextual labialization does tend to be more perceptible in certain restricted environments.

0. Introduction

This paper deals with the allophonic labialization of consonants before round vowels in Nawuri, a Kwa language of Ghana.¹ While such labialization is generally not very audible, spectrographic evidence suggests that it is strongly present,

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¹This study is based on the dialect of Nawuri spoken in the village of Kitare. Snider [1989c] includes Nawuri in his Oti Guang branch of the North Guang sub-group of Guang. Guang is itself part of the Tano family, which falls within Stewart's [1989] (New) Kwa.

and indeed that consonants which occur before round vowels may surface phonetically with a degree of lip-rounding comparable to that of the contrastively labialized consonants which occur in the language before non-round vowels. On the basis of this evidence, I propose that contextual labialization in Nawuri should be accounted for with a phonological rule that assigns a [+round] feature specification to consonants occurring before round vowels, rather than treated as a purely low-level transitional process. This analysis is further supported in that it allows for a plausible explanation of some phonetically labialized consonants that arise in connection with two other phonological processes occurring in the language.

After discussing my phonological analysis and its implications, I turn to the question of why allophonic lip-rounding, though physically present to a significant degree, is rarely very audible, a question made more interesting by the facts that (1) the environments in which contextual labialization does tend to be somewhat more perceptible are not the kinds of environments in which we might expect (through a consideration of purely articulatory factors) greater lip-rounding and that (2) contextual labialization in a number of other Ghanaian languages is also reported to occur more readily or more strongly in these same kinds of environments.

1. Background

There is surface contrast in Nawuri between the labialized consonants k^w , \check{c}^w , s^w , b^w , p^w , f^w , and m^w ,² and the non-labialized consonants k , \check{c} , s , b , p , f , and m , as exemplified in (1). In presenting data throughout this paper I omit certain phonetic details irrelevant to the main issues. A fuller description of Nawuri phonology is found in Casali [1988].

(1)	<u>labialized</u>		<u>non-labialized</u>
a.	$k^w\iota:$	‘to differ’	$k\iota:$ ‘to look’
b.	$gada:\check{c}^w\varepsilon:$	‘gecko’	$\check{c}\varepsilon:gi$ ‘to change’
c.	$s^wa:$	‘to be wounded’	$sa:$ ‘to draw water’
d.	$b^w\iota:$	‘to wither’	$b\iota:$ ‘to sing’
e.	$p\omega p^w\varepsilon:$	‘new’	$p\iota p\varepsilon:$ ‘red’
f.	$f^wa:la$	‘to greet’	$fa:ra:$ ‘to start’
g.	$g\iota lam^w\varepsilon:$	‘tiger nut’	$g\iota m\varepsilon:$ ‘duck’

²Contrast between $[\check{c}]$ and $[\check{c}^w]$ and between $[m]$ and $[m^w]$ is marginal. In a wordlist of about 1500 items, the forms in (1b) and (1g) are the only examples I have of $[\check{c}^w]$ or $[m^w]$ before non-round vowels.

All of these examples show contrast before a following non-round vowel, and this is in fact the only environment in which labialized and non-labialized consonants contrast in Nawuri.³ Whatever (allophonic) labialization exists on consonants occurring before round vowels is usually not very audible; moreover, native speakers do not appear to distinguish these consonants from ordinary non-labialized consonants,⁴ e.g. they identify the *s* of *sɔ:* ‘to buy’ with the non-labialized *s* of *sa:* ‘to draw water’ and not with the labialized *sʷ* of *sʷa:* ‘to be wounded’. Despite the fact that such labialization is not easy to hear, however, spectrographic evidence (presented below) indicates that consonants occurring before round vowels in Nawuri may actually bear a significant degree of lip-rounding.

2. Phonological and Phonetic Rules

Many current approaches to phonology assume a distinction between *phonological* rules, which fill in or alter the values of binary features, and *phonetic* implementation rules, which convert the representations resulting from the application of the phonological rules into more detailed representations in which scalar (multi-valued) features may appear in place of binary ones. In recent years much attention has been focused on the factors which determine whether a rule is phonological or phonetic (cf. Kiparsky [1985], Mohanan [1986], Pulleyblank [1986]). While a clear consensus has yet to emerge, processes that operate in gradient fashion are typically regarded as phonetic, especially where they involve universal tendencies that are directly attributable to the mechanics of speech production, e.g. the tendency for any vowel to have at least a slight degree of nasalization when adjacent to a nasal consonant. On the other hand, processes that operate categorically to change one contrastive segment into another, e.g. a “morphophonemic” process that lowers *i* to *e* in a language in which these two vowels contrast, are generally assumed to be phonological.

Since the labialization of consonants before round vowels in Nawuri is not very audible and since a certain amount of anticipatory rounding before round vowels is almost certainly inevitable in any language, it would be natural to assume that contextual labialization in Nawuri is simply an automatic transitional process that

³In a study of the Kpandai dialect of Nawuri, which differs in certain respects from the Kitare dialect described in this paper, Sherwood [1982] recognizes a contrast between labialized and non-labialized consonants before round vowels as well as non-round vowels, citing minimal pairs such as [bɔ] ‘to be’, [bʷɔ] ‘to swear’ (both with falling tone). I agree with Sherwood that these two forms are in fact phonetically different; I disagree, however, that the principle phonetic contrast resides in the labialization of the initial consonants, and would transcribe these words (in both the Kpandai and Kitare dialects) as [bɔ] (‘to be’) and [bɔ] (‘to swear’).

⁴In observing the writing practices of native speakers (including those with no prior instruction in writing Nawuri words), for example, I have not found anyone to use anything other than an ordinary (non-labialized) consonant symbol to represent consonants occurring before round vowels, although they virtually always employ some additional symbol, e.g. a *w* or round back vowel, to indicate labialization before non-round vowels.

results in a slight degree of anticipatory rounding on a consonant preceding a round vowel. It would then be appropriate to account for this labialization with a phonetic rather than a phonological rule. There is good reason, however, to believe that the contextual labialization of consonants in Nawuri is actually something more than a phonetic transitional process. Spectrographic evidence presented in the next section implies that consonants occurring before round vowels may surface with just as much lip-rounding as their contrastively labialized counterparts that occur before non-round vowels, i.e. the process does not appear to be gradient. This argues that contextual labialization in Nawuri should be treated as a phonological rule spreading the feature [+round] to consonants before round vowels, rather than as a purely phonetic phenomenon.

3. Evidence of Labialization

This study of Nawuri labialization is based on the spectrographic analysis of tape recordings of Nawuri speech which I made in Ghana during a three year period from 1985-1988. Most of the analysis was carried out at the phonetics laboratory of the University of Texas at Arlington during the period from January to May 1989. In investigating anticipatory labialization before round vowels, I chose to focus on the consonants *k* and *s*, both of which have contrastively labialized counterparts to which they may be compared. Also, since neither of these segments involves lip closure as a primary feature, the lips should have complete freedom to round during the production of the consonant itself in anticipation of a following round vowel. If there is a significant degree of assimilatory labialization in Nawuri, therefore, these two consonants should be likely candidates to undergo it.

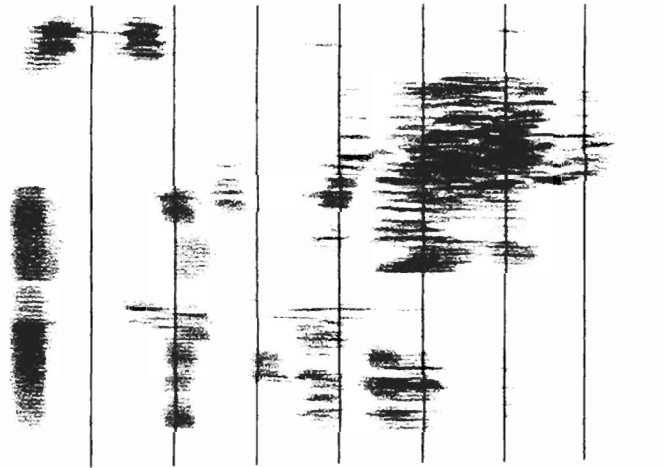
3.1. Labialization of *s*. Spectrograms showing non-labialized *s* before non-round vowels appear in (2).

(2) See Figure 2

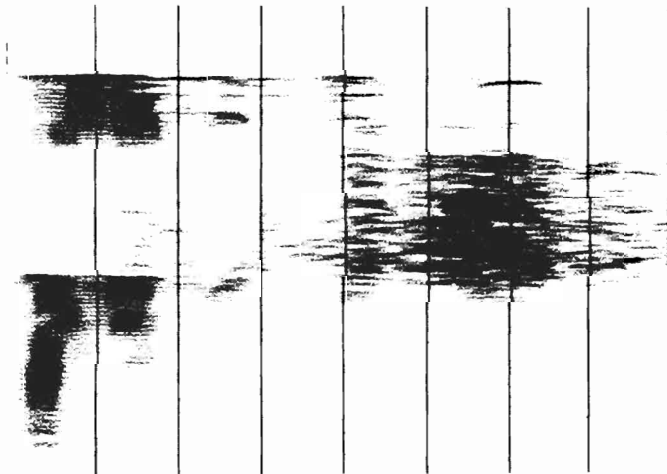
In all three examples, the spectral energy of *s* has its heaviest concentration somewhere between about 5500 and 6500 hz. Below about 4000 hz, there is only relatively weak energy. These may be compared with the examples showing clearly labialized *s^w* before non-round vowels in (3), all of which have their strongest energy concentration in a much lower frequency zone around 4000 hz.

(3) See Figure 3

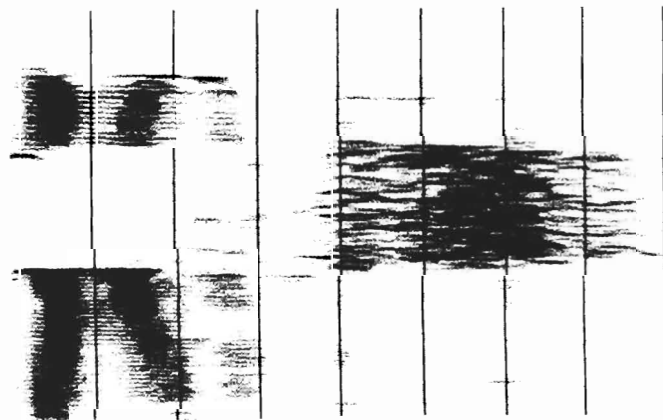
(2a) asiri 'secret'

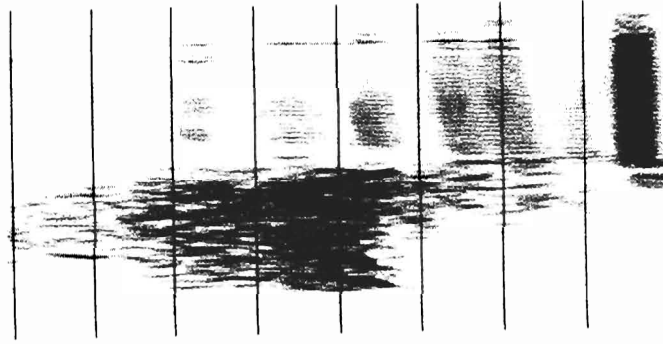
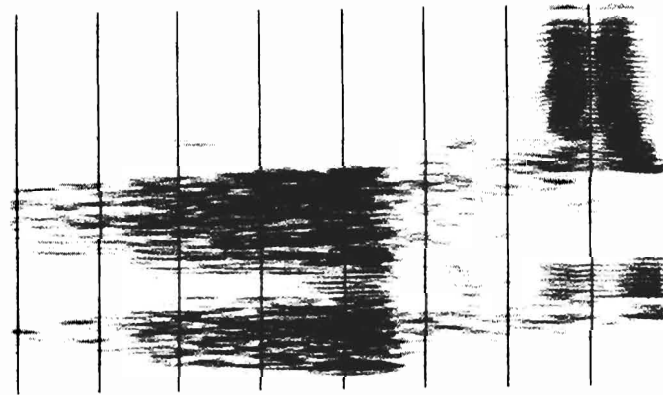
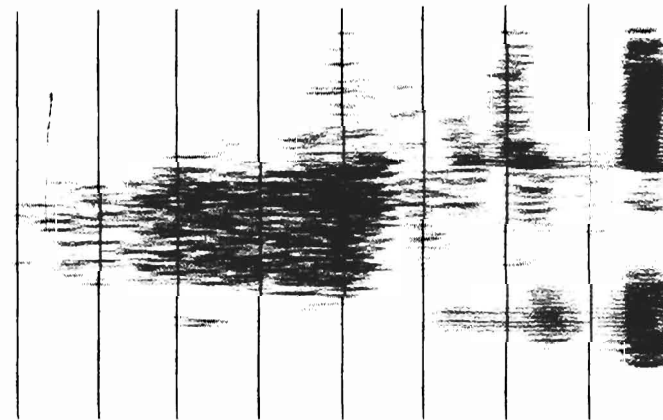


(2b) asuŋ 'controversy'



(2c) gasi 'ground'



(3c) ns^wli 'to sip'(3b) sos^waa 'to grease'(3a) ns^wli 'long'

The lower spectral energy peak evident in these spectrograms of s^w is exactly the effect which would be expected to result from a superimposed lip-rounding (cf. Pickett [1980:159]). A lowering of spectral energy might also be achieved by a movement of the tongue body toward the velar position. My impression is that s^w is not appreciably velarized in Nawuri however.

Looking now at the spectrograms in Figure (4), which show s before round vowels, it is immediately apparent that these display the same energy concentration in the vicinity of 4000 Hz which is characteristic of the spectrograms showing s^w before non-round vowels in (3).

(4) See Figure 4

A particularly interesting example is found in (3b): the single word $s\omega s^w a$: contains both a clearly labialized s^w before a non-round vowel and an underlyingly non-labialized s before a round vowel. The resemblance between the two segments is striking; indeed there is nothing in their spectrograms which would indicate that they are qualitatively different. On the basis of this evidence, I conclude that the consonant s bears significant labialization before round vowels.

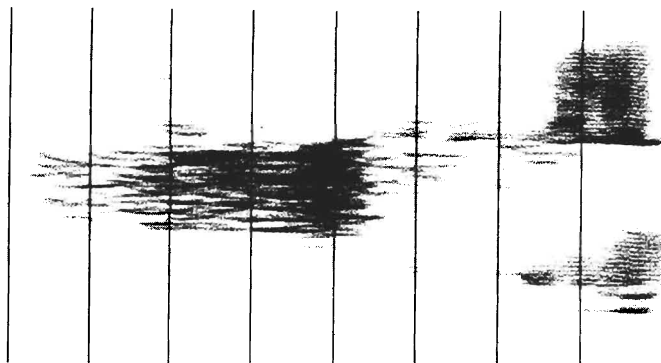
3.2. Labialization of k . Since, in contrast to s , no spectral energy is visible during the actual articulation (closure portion) of k itself, the contextual labialization of this consonant was investigated indirectly using other sources of evidence. The first source of evidence involves spectrograms of utterances in which k appeared in a V__V frame. My assumption was that while the coarticulatory effects of a round vowel on a preceding k would not be directly visible in the spectrogram of the k itself, these effects could extend as far back as the preceding vowel, in which case they would be visible in the spectrogram of that vowel. This is basically the technique used by Öhman [1966].

Figure (5) shows spectrograms of examples in which the second vowel in a V k V (or V## k V) sequence is back and round.

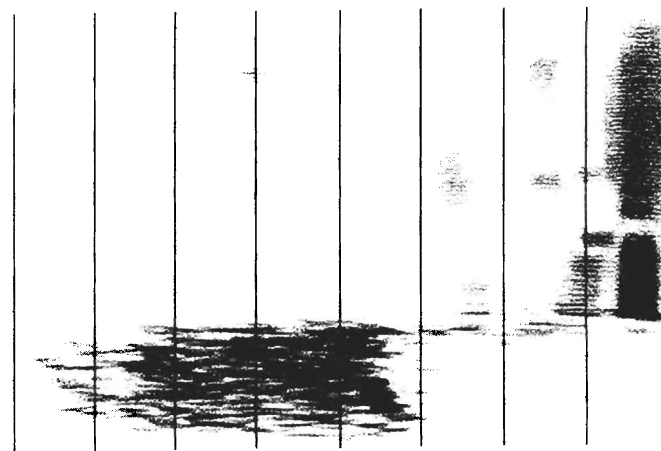
(5) See Figure 5

The relevant characteristic is the second formant trajectory of the vowel immediately preceding k : in every case, F_2 is noticeably lower toward the end of this vowel than at the beginning. These spectrograms may be contrasted with those in (6), showing V k V sequences in which k is followed by a non-round vowel.

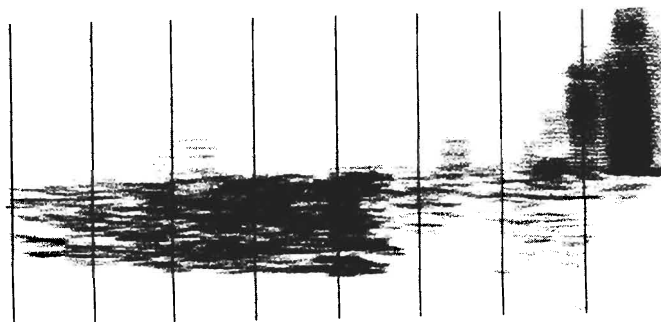
(6) See Figure 6



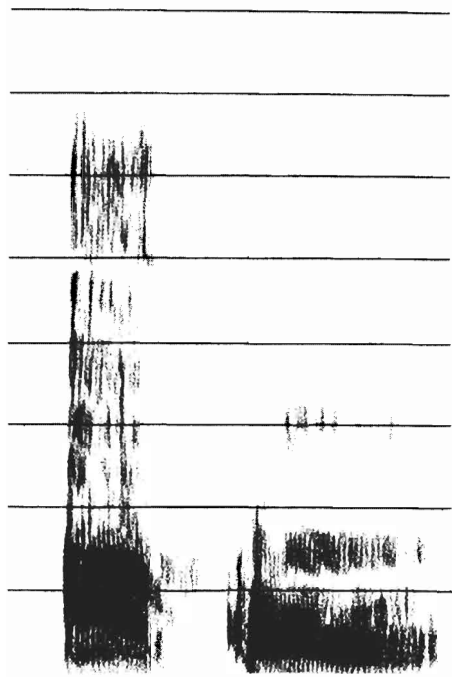
(4c) nso 'ash'



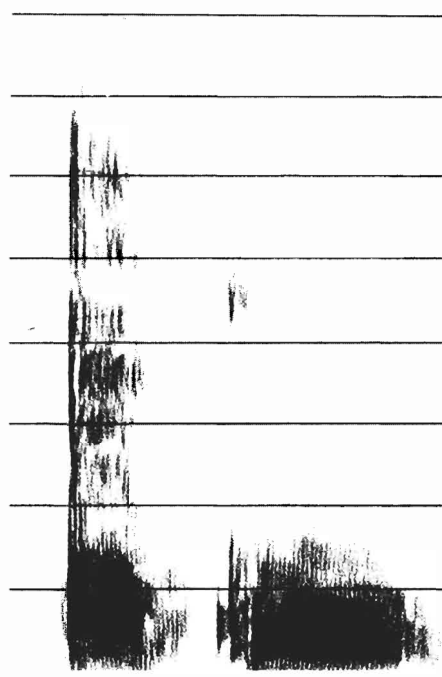
(4b) soomu 'bucket'



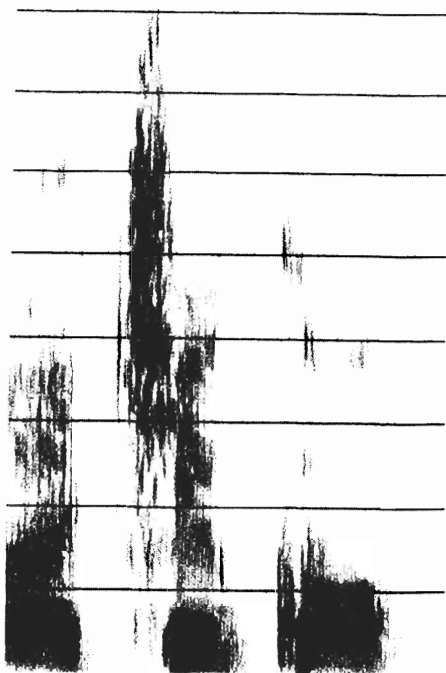
(4a) so 'to have'



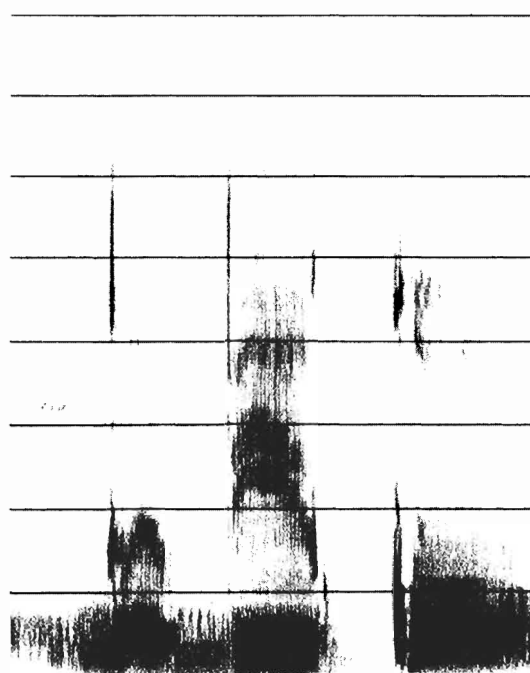
(5a) akon 'hunger'



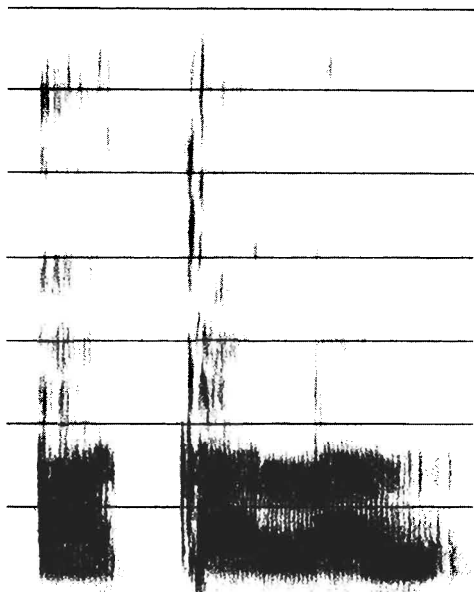
(5b) akoo 'parrot'



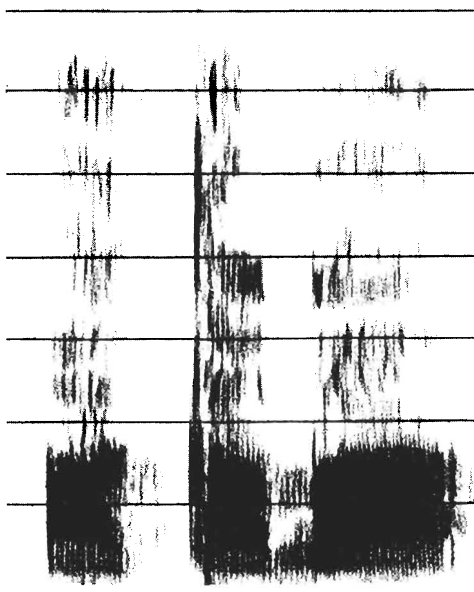
(5c) ɔʒii koo 'some woman'



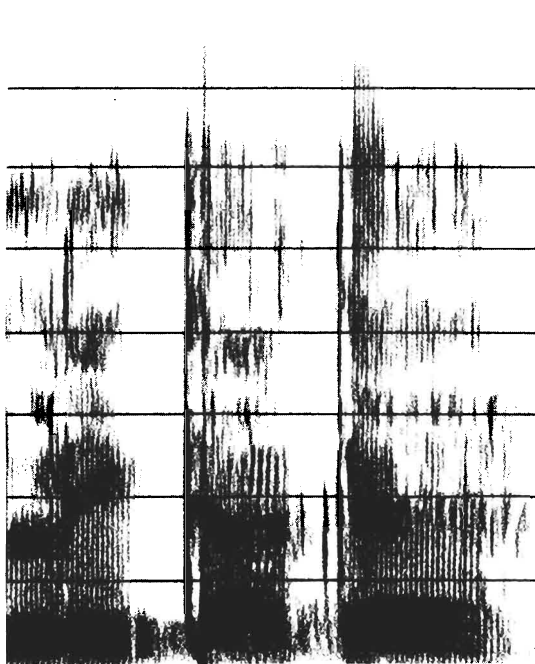
(5d) gebii koo 'some child'



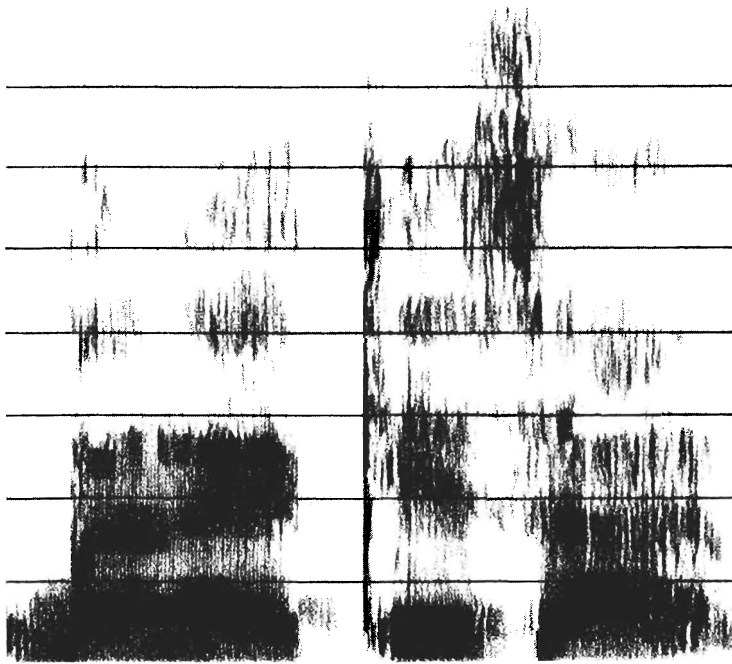
(6a) akalaŋ 'crocodile'



(6b) akaba 'skin disease'



(6c) lɪkaakɛ 'following day'



(6d) gbanɛ kɪsa 'a horse to care for'

In every one of the examples in (6), the second formant of the vowel preceding *k* is either level or rising.

A falling second formant trajectory in a vowel preceding a *k*-plus-back-round-vowel sequence could be attributed either to an anticipatory backing of the tongue body, an anticipatory lip-rounding, or both. Since the vowel following *k* is both back and round, a likely possibility is that both types of anticipation are involved.⁵ Clearly, whatever anticipatory lip-rounding extends to the first vowel in a *VkV* sequence must also be present during the articulation of the *k* which intervenes between this vowel and the following round vowel that is being anticipated. Hence, there is indirect evidence of anticipatory lip-rounding during the production of the consonant *k* in the *VkV* sequences in (5).

A second source of evidence for the labialization of *k* before round vowels comes from the spectral characteristics of the burst that follows the release of this consonant. Where significant lip-rounding is present, we should expect the most intense spectral energy of the burst to occur at lower frequencies than where no lip-rounding is present. In each of the spectrograms in (5) (in which *k* is followed by a round vowel), a strong concentration of energy below 1000 hz is visible in the burst following the release of *k*. In none of the spectrograms in (6) (in which *k* is followed by a non-round vowel), on the other hand, does the spectral energy in the burst following *k* show a maximum intensity in such a low frequency zone.

More precise measurements of the spectral characteristics of the release bursts of various instances of *k* were made using the CECIL (Computerized Extraction of Components of Intonation in Language) and SPECTRUM software programs included in the Speech Analysis System produced by the Summer Institute of Linguistics. The frequency at which the maximum spectral energy of the burst ("burst frequency") occurred was measured for four instances of *k*^w before a non-round vowel and five instances of *k* before a round vowel.⁶ The results of these

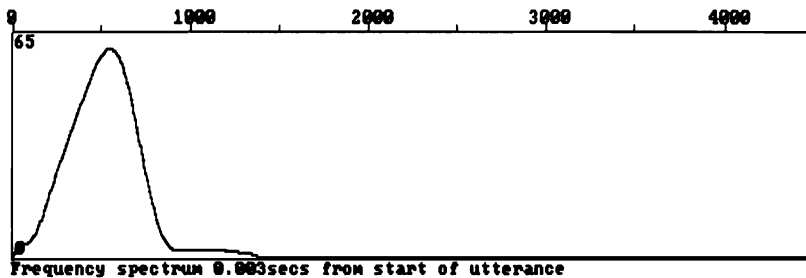
⁵In his study of coarticulation in VCV utterances in Swedish and English, Öhman [1966] concluded that where the second formant of the first vowel in a VCV sequence was lowered in anticipation of the vowel in the following syllable, most of the lowering was due to tongue movement rather than anticipatory lip-rounding. This does not mean, however, that lip-rounding was not involved, but only that its effect on F_2 was not as significant as that of the tongue: "naturally, the labial gesture will have some influence, but the lingual factor dominates" [Öhman 1966:163].

⁶The measurements were made in the following manner. First, digitized representations of tape recorded utterances were produced using the CECIL program at a sampling rate of 19500 hz. The same program was then used to extract, as nearly as possible, a portion consisting of just the release burst and aspiration of the relevant *k* consonant in each utterance. This extracted portion was stored as a floppy disk file, which was later accessed by the SPECTRUM program to produce a two-dimensional spectral display like the one below for the word *kōma*: 'all' (horizontal axis = frequency in hz, vertical axis = intensity (relative scale)). In every case, the spectrum was taken at a point as close to the beginning of the burst-plus-aspiration segment as possible.

measurements are shown in (7a) and (7b) respectively (the consonant to which each measurement refers is underlined).⁷

(7)	<u>word</u>	<u>gloss</u>	<u>burst frequency (hz) of k/k^w</u>
a.	<u>k</u> ^w ɫ:	'to differ'	620
	kɔ <u>k</u> ^w ɫ:	'different'	730
	<u>k</u> ^w a:ta:	'tortoise'	570
	<u>k</u> ^w aya:	'soap'	460
b.	<u>k</u> ɔ	'to fight'	760
	<u>k</u> odu: ⁸	'banana'	700
	<u>k</u> ɔk ^w ɫ:	'different'	590
	<u>k</u> ɔma:	'all'	540
	<u>k</u> uŋ	'to cover'	430

The burst frequencies in (7b) compare quite closely to those in (7a). This result is consistent with the assumption that *k*'s occurring before round vowels possess a



Since the current version of SPECTRUM does not provide an actual numeric value for the frequency at which an intensity peak occurs, it was necessary to estimate this by making measurements with a ruler on a paper printout of the spectral display and using the ratio:

$$\frac{\text{peak frequency (hz)}}{\text{horizontal distance in cm from 0 to peak}} = \frac{1000 \text{ (hz)}}{\text{horizontal distance in cm from 0 to 1000 hz}}$$

⁷The words on which the measurements were made were all taken from a tape recording of a list of words recited by an adult male Nawuri speaker. The four words in (7a) represent the only instances of /*k*^w/ which occur in the word list. The five words in (7b) were chosen more or less at random (although care was taken to include examples involving *k* before each of the four round vowels in the language) from among the (many) words in the list which have an initial *k* preceding a round vowel. The same token of the word *kɔk^wɫ:* 'different' was used for the measurements in both (7a) and (7b).

⁸The word *kodu:* 'banana' is borrowed from Twi.

degree of lip-rounding similar to that of the clearly labialized k^w 's which occur before non-round vowels. If, on the other hand, contextual labialization were simply a gradient transitional process producing a slight degree of lip-rounding, we might have expected to find that the burst frequencies of k 's before round vowels were not as low as the burst frequencies of contrastively labialized k^w 's that occur before non-round vowels.⁹

3.3. Summary. The spectrographic evidence presented in this section suggests that consonants occurring before round vowels in Nawuri may surface with a significant degree of anticipatory labialization. There is no indication that this labialization process is in any way gradient. Rather, it would appear that the contextual labialization of s or k before a round vowel produces a degree of lip-rounding comparable to that of the contrastively labialized s^w 's and k^w 's which occur before non-round vowels. This argues that contextual labialization in Nawuri should be treated as the result of a phonological rule assigning the feature specification [+round] to consonants occurring before round vowels rather than as a purely phonetic process assigning an intermediate degree of roundness to consonants in this environment. In the following two sections I briefly outline an analysis incorporating such a rule and show how this analysis can shed light on the treatment of two other phonological processes in Nawuri.

4. Sources of Labialized Consonants: Basic Analysis

A complete analysis of labialization in Nawuri must account for both the labialized consonants which contrast with non-labialized consonants before non-round vowels, as in (1), and the contextually labialized consonants which occur before round vowels. This paper is primarily concerned with the latter. For our present purposes, I simply assume that the seven labialized consonants which occur contrastively before non-round vowels are derived from underlying labialized conso-

⁹This would seem to be the case in English, for example. The burst frequency measurements below were made (in exactly the same manner as the measurements in (7)) from the speech of a male speaker of American English:

<u>word</u>	<u>burst frequency (hz) of k/k^w</u>
question	590
query	950
quail	780
caught	1200
cool	1000
coat	1300

The burst frequencies of the English k 's occurring before round vowels (bottom group) are not as low as those of the contrastively labialized English k^w 's, nor are they as low as the burst frequencies of the contextually labialized Nawuri k 's in (7b).

nant phonemes which differ from their non-labialized counterparts only in that they are positively specified for the feature [round]. These seven underlying [+round] consonants are listed in (8):

(8) $k^w \quad \check{c}^w \quad s^w \quad b^w \quad p^w \quad f^w \quad m^w$

Under this analysis, the underlying form of a word like [$k^w\iota$:] 'to differ' (cf. (1a)) will simply be / $k^w\iota$:/, where / k^w / is identical to / k / in all its feature specifications except that it is [+round].

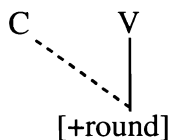
In addition to these seven labialized consonant phonemes, Nawuri has a total of twenty-one other consonant phonemes, as listed in (9). (The phonemic status of r is open to doubt, as [r] is very nearly in complementary distribution with [d]. An additional phoneme / h / occurs in a few loan words; it may be regarded as extrasystemic.)

(9)

labials:	p, b, f, m, w
alveolars:	t, d, s, l, r, n
(alveo-)palatals:	\check{c}, j, η, y
velars:	k, g, η
labio-velars:	$kp, gb, \eta m$

With the exception of w , none of these consonants is underlyingly [+round]. Before round vowels, i.e. u, ω, o, \circ , they will become [+round] through the application of a phonological rule:

(10) **Labialization**



Rule (10) will apply to all the consonants in (9), both those which have underlyingly labialized counterparts ($k, \check{c}, s, b, p, f, m$), and those which do not. Admittedly, nothing we have seen so far requires this assumption; since direct spectrographic evidence of contextual labialization has been obtained only in the case of the consonants s and k , both of which have underlyingly labialized counter-

parts, a plausible alternative assumption would be that only the seven consonants with contrastively labialized counterparts become [+round] before round vowels. Motivation for the claim that *all* consonants become [+round] before round vowels will be given in §5, where I show how this assumption allows for a simple and natural treatment of other aspects of Nawuri phonology.

Since the labialization brought about by rule (10) is entirely predictable, I will generally not indicate it explicitly in my phonetic transcriptions. Only before non-round vowels will labialization be directly indicated (with the familiar superscript *w*). This will also serve as a reminder that it is only before non-round vowels that labialized consonants are clearly audible. This notational practice should not, however, be allowed to obscure the claim inherent in rule (10) that all consonants before round vowels are in fact phonetically [+round].

5. Labialization and other Phonological Processes

In this section I show how positing a general phonological rule that labializes consonants before round vowels allows for a simpler and more explanatory treatment of two other phonological processes in Nawuri: a vowel fronting process which applies in fast speech to convert a back round vowel to a front non-round vowel before the consonant *y* and a vowel elision process which applies when clusters of non-identical vowels arise across word boundaries. These are discussed in §§5.1 and 5.2 respectively. In §5.3, I consider (and reject) some alternative ways in which these processes might be analyzed *without* relying on a general labialization rule applying to all consonants occurring before round vowels.

5.1. Labialization and Vowel Fronting. In fast speech, underlying back vowels which occur before the consonant *y* frequently surface phonetically as front non-round vowels.¹⁰ This is illustrated in (11). Note that if the fronted vowel is underlyingly round, as in (11c-e), the preceding consonant surfaces phonetically with clearly audible labialization.

- (11) a. *kuruma ye gbaɲe*: → *kurume ye gbaɲe*: ‘a donkey and a horse’
 b. *sa ya*: → *sɛ ya*: ‘give (something) to Yaa’
 c. *ge-lu: ye lewu* → *gel^wi: ye lewu* ‘war and death’

¹⁰The fronting and unrounding of a word-final back round vowel may also take place before a word-initial front vowel, e.g. /*du*: *ijo*/ ‘plant yams’ → [*d^wi*: *ijo*]. (Only long vowels ever exhibit fronting in this environment, since word-final *short* vowels regularly undergo elision before a following word-initial vowel. See §5.2 for more discussion.) To facilitate the discussion, I choose to ignore this additional data and focus only on cases involving fronting before the consonant *y*. Nothing of importance is affected by this.

- d. *kotoku ye čemisi* → *kotok^wi ye čemisi* 'a sack and a headpan'
 e. *gə-tə yu:ri-sa* → *gə^wt^wε yu:ri-sa* 'something stolen'

I assume that the fronting (and unrounding) of the word-final vowels in these examples is accomplished by a rule whose precise formalization need not concern us; it then remains to account for the labialization which surfaces on the consonants in (11c-e). Under the present assumption that all consonants are labialized before round vowels in Nawuri, the explanation for this labialization is straightforward: the consonants become [+round] by rule (10), prior to the operation of the vowel fronting rule. This is illustrated in the derivation of (11e) shown below:

- (12) Underlying Form: */gə^t tə yu:ri:sa/*
 Labialization (10): *gə^wt^w tə yu:ri:sa*
 Vowel Fronting: *gə^wt^wε yu:ri:sa*

Note that in this analysis the labialization of the consonant *t* in *gə^t tə* is independent of the fronting of the following vowel; even where the fronting process is inapplicable (as when the word *gə^t tə* is pronounced in isolation or before a word beginning in a consonant other than *y*), rule (10) predicts that this consonant will be phonetically [+round]. The fact that this labialization is generally not very audible need not be considered a serious problem for this analysis, since we have already seen spectrographic evidence that consonants may bear a significant degree of labialization before round vowels even where such labialization is not very perceptible.

5.2. Labialization and Vowel Elision. There is a general rule in Nawuri which converts a sequence of two short non-identical vowels arising across a word boundary to a single lengthened vowel which, in the simplest case, is identical to the *rightmost* of the two original vowels:¹¹

- (13) a. *na:tu ə-pi:* → *na:tə:pi:* 'a cow's tail'
 b. *gi-bite ə-bu* → *gibito:bu* 'a girl's room'
 c. *kəntu əsi* → *kənta:si* 'near the elephant'

¹¹A fuller treatment of the processes which may affect sequences of vowels arising across word boundaries in Nawuri is given in Casali [1988]. Analyses of similar (though not entirely identical) vowel sandhi processes in the closely related language Chumburung are given in Snider [1985, 1989b].

When the first vowel is round and the second vowel is non-round, not only is the underlying vowel sequence converted to a single lengthened vowel, but the consonant preceding this vowel surfaces with clearly audible labialization:

- (14) a. $f\omega\ \iota-p\omega$ → $f^w\iota:p\omega$ ‘your soup’
 b. $s\omega\ \iota-ca:si$ → $s^w\iota:ca:si$ ‘to have fowls’
 c. $gu-du\ a-sa$ → $gud^w a:sa$ ‘thirteen’

When *both* vowels are round, whatever labialization is present on the consonant preceding the underlying word-final round vowel is not very audible phonetically. In contrast to (14b), for example, the phrase $s\omega\ \text{ɔ}k\omega\iota:$ ‘to have a boat’, surfaces as $s\text{ɔ}:k\omega\iota:$, without clearly perceptible labialization on the initial *s*. Nevertheless, in keeping with the spectrographic evidence of §3, I assume that this consonant is in fact phonetically labialized.

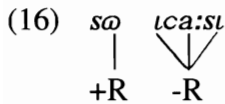
As with the vowel fronting data in the previous section, the treatment of the examples in (14) is straightforward, given the inclusion of the labialization rule (10) in the grammar of Nawuri. Assuming that the data in (13) are accounted for by a rule which deletes the first in a sequence of two adjacent vowels, with compensatory lengthening of the remaining vowel, the data in (14) will be accounted for automatically as a result of the interaction of this rule with the labialization rule (10). This is illustrated in the derivation of (14b) below:

- (15) Underlying Form: $/s\omega\ \iota ca:si/$
 Labialization (10): $s^w\omega\ \iota ca:si$
 Vowel Elision: $s^w\ \iota:ca:si$

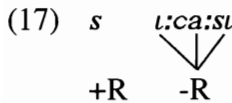
5.3. Alternative analyses. I have shown how the assumption that Nawuri has a phonological rule assigning the feature specification [+round] to all consonants before round vowels allows for a straightforward and natural treatment of some data related to two other processes in the language. The rules used in this analysis are both independently motivated and phonologically natural. In the present section, I consider two alternative analyses which might be advanced to account for the same data without positing a general labialization rule such as (10). It will be shown that both of these analyses are inadequate in some respect.

The first analysis makes crucial use of the assumption that the feature [round] appears on its own autosegmental tier, separate from the other features which comprise the segmental feature matrices. Given this assumption, the initial representa-

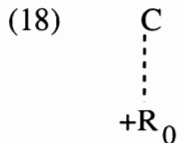
tion (prior to the application of the vowel elision rule) of (14b) might be as in (16). (Here +R is used to represent a [+round] autosegment, -R a [-round] autosegment. The symbol ω in (16) should now be understood as standing for the set of features [+high], [-low], [+back], [-ATR], i.e., for all the usual features of ω *except* the feature [+round], which does not appear together with the other features since it is represented autosegmentally. Similarly, ι now represents all of the usual features of ι *except* [-round].)



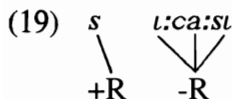
Provided that the vowel elision rule is formulated so as to delete only the segmental feature matrix of a word-final vowel (leaving any features on autosegmental tiers unaffected), it will convert the representation in (16) to the one in (17) below:



At this stage, all that is needed is a rule which attaches a floating [+round] autosegment to an accessible consonant, as in (18). (Here the symbol $+R_0$ is used to indicate a [+round] autosegment which is not associated with any segment.)



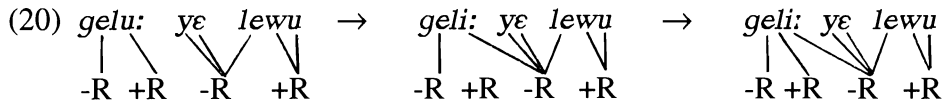
This rule will link the floating +R autosegment in (17) to the consonant *s*. (Note that *s* is the only consonant accessible to this autosegment, since linking +R to any other consonant would lead to a crossing of association lines.) The result is the representation in (19), which corresponds to the phonetic form $s^w \iota:ca:sl$.



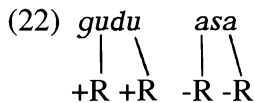
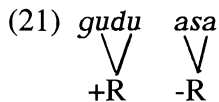
This analysis has some appeal to it, in that it provides an elegant explanation for the consonantal labialization that shows up when a following round vowel is deleted in the examples in (14). This labialization derives from the ability of the

feature [round], as an autosegmental feature, to survive the deletion of the vowel it was associated with and reassociate with a neighboring segment. This kind of ability to survive deletion has been well-documented in the case of tone, and it might seem reasonable to expect that other phonological features should, in some languages, exhibit similar behavior.

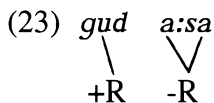
The analysis can also be readily extended to the vowel fronting examples of §5.1. Assuming that the fronting of a back vowel before *y* also involves the delinking of any [+round] autosegment associated with this vowel, rule (18) would then be free to reassociate this “floating” [+round] autosegment with the appropriate consonant. This sequence of events is sketched in (20).



Despite the attractiveness of this analysis, however, it runs into difficulty with an example like (14c). Assuming that the Obligatory Contour Principle (OCP) holds at the word level in Nawuri, the representation of this example at the stage when vowel elision is to apply must be as in (21) rather than as in (22):



Applying vowel elision to (21) yields:



At this point rule (18) is inapplicable, since the [+round] autosegment is still associated with the first vowel, i.e. it is not floating. The output of the derivation is therefore the incorrect form **guda:sa* instead of the desired *gud^wa:sa*.

This difficulty might be circumvented by assuming that the OCP does *not* govern the roundness tier at the word level in Nawuri, in which case vowel elision could apply to the representation in (22) rather than the one in (21). This would lead to the desired output, i.e. *gud^wa:sa*. There is strong language-internal evidence, however, that the autosegmental representation of *gudu* ‘ten’ should actu-

ally be as in (21) and not as in (22). The initial syllable *gu* in this word is a very common singular noun class prefix whose vowel always agrees in roundness (and also tongue root advancement) with the vowel in the initial syllable of the following noun stem.¹² Within autosegmental phonology, the standard treatment of such “harmonizing” affixes (cf. Clements [1981], Clements & Sezer [1982]) is to assume that they carry no autosegment of their own for the harmony feature in question (in this case [round]); instead, they will become associated with the nearest autosegment of the stem through autosegmental spreading. This assumption clearly rules out a representation such as (22), in which the prefix *gu* is associated with a [+round] autosegment of its own and dictates that the vowel of the prefix must rather “share” the [+round] autosegment which is part of the lexical representation of the stem *du*, as in (21). While this need not mean that the OCP always holds at the word level in Nawuri, the fact that the OCP is not violated in the case of *gudu* (and numerous other words of the same structure) does mean that the analysis as presented will be incapable of correctly deriving examples like (14c). Moreover, there seems to be no simple way of modifying the analysis to overcome this problem.

The other analysis to be considered is one which accounts for the examples in (14) by means of a glide formation rule that converts an underlying word-final short round vowel to a glide *w* before a following word-initial non-round vowel (with compensatory lengthening of the latter). In the case of (14b), for example, this would lead to the surface form *swi:ca:si*.

In contrast to the analysis considered above, there is no crucial evidence to show that a glide formation analysis is untenable in Nawuri. The chief reason for not preferring it to the analysis I outlined in the preceding sections is simply that it is less general. Whereas in the analysis of §§5.1 and 5.2 the same rule (10) is used to account for the labialization which surfaces in both (11) and (14), the glide formation rule would apply only to the latter. If the glide formation analysis were adopted then a separate rule would have to be formulated to account for the vowel fronting examples in (11).

There is, in addition, a minor objection to the glide formation analysis in Nawuri stemming from the fact that the labialized consonants derived under this analysis are represented phonetically as sequences of a consonant followed by *w*, rather than as unitary [+round] segments. Quite apart from the issue of the number of segments involved, the [+high], [+back] feature specification of the consonant *w* conflicts with the fact that the labialized consonants in the data in (14) do not appear to involve any significant raising or backing of the tongue body during their production, i.e. they are not phonetically velarized. While this discrepancy could conceivably be regarded as a matter of low-level phonetic detail, one must question

¹²In slow speech, this agreement may however be blocked by a stem-initial non-round labial consonant, i.e. *p*, *b*, *f*, *m*, *kp*, *gb*, or *ɣm*.

how far we should go in allowing the output of the phonological rules to contain feature specifications which have no basis in articulatory reality.

6. Nawuri Labialization and Speech Perception

In the preceding sections, I presented evidence indicating that labialization before round vowels should be treated as a phonological (rather than a purely phonetic) process in Nawuri, and I discussed some implications of this claim for the analysis of other aspects of Nawuri phonology. I have not so far, however, considered the question of why this labialization, if it is indeed present to a significant degree, is not very audible. It is this question which forms the subject matter of §6.1.

A related and equally intriguing question arises in connection with the fact that, while labialization before round vowels is not very perceptible, there are a few environments in which it does tend to be somewhat easier to detect. What makes this situation interesting is the fact that the environments in which contextual labialization is more noticeable are not the kinds of environments which we would expect, on articulatory grounds, to contribute to a more pronounced rounding of the lips. I suspect, in fact, that consonants are not actually more strongly labialized in these environments, but that there are acoustic factors which render labialization more perceptible in these contexts. In §6.2 I advance some specific, though tentative, suggestions as to the kind of acoustic factors which may be involved.

6.1. The Perceptual Filter Hypothesis. On one level, the fact that labialization is not readily perceived before round vowels in Nawuri might be viewed as a simple consequence of the fact that any property of a segment is likely to be more difficult to detect against a less contrastive background. Just as a white object is more easily identified against a dark background than against a white one, we might expect labialized consonants in any language to be more salient before non-round vowels (to which they are less similar) than before round vowels. (It is thus not surprising that many languages have a contrast between labialized and non-labialized consonants only before non-round vowels.)

A fuller explanation (which addresses the question of *why* properties of segments are more difficult to perceive against a less contrastive background) is suggested by the work of linguists such as Ohala [1981] and Kawasaki [1986], who claim that a listener's speech perception mechanism automatically "factors out" features of the signal which could be attributed to the perturbing influence of an adjacent segment, e.g. nasalization before a nasal consonant:

listeners' expectations in perceiving speech play a crucial role in giving rise to sound patterns in language...whatever a listener expects to hear, that is, some kind of automatic or commonly encountered perturbation of one segment by another, may be taken for granted and factored out of the phonetic percept constructed for a word, as long as the segment responsible for the perturbation is

detected... If the perturbing segment is not detected, for whatever reason, then the perturbation is not expected and is not factored out; it is then included as part of the phonetic percept of the word. [Kawasaki 1986:86,87]

Among the studies which support this hypothesis (henceforth the “perceptual filter hypothesis”) is an investigation by Kawasaki [1986] into the effect which a listener's perception of a nasal consonant has on his ability to perceive the (contextually induced) nasality of an adjacent vowel in English. She found that subjects became more able to perceive the nasality of vowels flanked by nasal consonants as the amplitudes of these consonants were attenuated.

The perceptual filter hypothesis has a straightforward application to contextual labialization. Since a certain amount of anticipatory lip-rounding before round vowels is probably inevitable in any language, it is likely that any normal speaker of a human language will have come to expect labialization in this environment and will therefore tend to “factor it out”, thus failing to perceive it. This will be the case not only when listening to one's own language, but to a foreign language as well. Presumably, this general tendency to “factor out” labialization before round vowels may be counteracted by other factors (such as a particularly strong articulatory degree of anticipatory lip-rounding or acoustic factors that may render labialization more salient in certain environments), for otherwise we would wrongly predict that contextual labialization would be imperceptible to all listeners under all circumstances. But while other factors may need to be taken into consideration, the perceptual filter hypothesis would seem to provide a plausible basis for explaining the general lack of perceptual salience of labialized consonants before round vowels.

Note that if the roundness of the conditioning vowel that follows a contextually labialized consonant were to be somehow removed (a situation analogous to Kawasaki's experiment with vowel nasalization), or if something were to prevent the listener from detecting it, the perceptual filter hypothesis predicts that the labialization of the consonant should become perceptually evident. There is reason to believe that this is exactly what is happening in the case of the Nawuri vowel fronting and vowel elision processes discussed in §5. In most environments in which Nawuri words ending in word-final round vowels may occur, the consonants which precede these vowels are not heard with clear labialization, even though there is reason to believe that they do in fact bear significant lip-rounding. But if the feature which conditions this lip-rounding, i.e. the roundness of the word-final vowel, is removed, as in the vowel fronting examples in (11c-e) or the vowel elision examples in (14), then the labialization becomes readily noticeable. In the case of vowel elision, it is especially interesting to note that where the word-initial vowel that follows the deleted vowel is itself round, no clear labialization is heard. A phrase like *sɔ ɔkɔli:* ‘to have a boat’ surfaces as *sɔ:kɔli:*, without clearly audible labialization on the initial *s*. The generalization, then, would seem to be that a consonant preceding an underlying round vowel is heard with clearly audible labi-

alization only when it surfaces phonetically before a non-round vowel. Under the perceptual filter hypothesis, this is just what we might expect.

6.2. Perception of labialization in different environments. While labialization before round vowels is never all that salient in Nawuri, it is somewhat more noticeable before mid round vowels, i.e. *o* and *ɔ*, than before high round vowels, i.e. *u* and *ɔ̄*. It is least perceptible before *u*. The nature of the consonant itself may also make a difference: labialization is most noticeable with the consonant *k*, but it may also be somewhat more noticeable with *ç* and with the labial consonants *p*, *b*, *f*, and *m*. Finally, the perception of labialization may also depend on the phonetic identity of the consonant, if any, which *follows* the round vowel responsible for conditioning the labialization. Labialization is more readily perceived when this following consonant is an alveolar¹³. (Where the round vowel preceding this alveolar consonant is non-high, the labialization of the preceding consonant may be even more perceptible.) To my ears, for example, the initial consonants of the words in (24), all of which have an alveolar as their second consonant, generally sound more labialized than do the initial consonants of the words in (25).

- (24) a. *kɔntu* 'elephant'
 b. *bɔtu* 'termite'
 c. *kotoku* 'sack'
 d. *fɔlɔɣi* 'to complain'
- (25) a. *kɔ:ɣi* 'to give birth'
 b. *bɔ* 'to swear'
 c. *ko:* 'far'
 d. *fɔɣi* 'to sweep'

From a purely articulatory standpoint, it is difficult to understand why these particular factors should be especially conducive to labialization. For a period of time, the implausibility of these conditioning factors led me to distrust my own auditory impressions. But after several years of exposure to the language, I am confident that, whether or not the statements of the preceding paragraph have any *articulatory* basis (I happen to think that they do not), they do embody valid generalizations about the environments in which contextual labialization is more audible.

My statement that contextual labialization tends to be more salient in these particular environments also finds some support in the Nawuri data of two other investigators, Sherwood [1982] and Snider [1989a]. In Sherwood's data, I counted a

¹³A following alveolar consonant may occur as the onset of the following syllable, or it may be a syllable-final [ɲ]. (Only nasal consonants may occur syllable-finally in Nawuri.)

total of twenty-four distinct morphemes in which a phonetically labialized consonant precedes a round vowel. These labialized consonants were, in order of frequency, k^w , b^w , p^w , m^w , f^w , j^w , h^w (the latter four each occurred in only one morpheme). In all cases, the round vowel following the labialized consonant was transcribed as a non-high vowel, o or ɔ .¹⁴ There were eighteen cases in which the labialized consonant was followed by another consonant in the same morpheme. In thirteen of these cases this following consonant was an alveolar; in three of the remaining five cases it was y (in these latter cases it is conceivable that the vowel fronting process discussed earlier might have played a role in rendering the labialization more conspicuous). In Snider's Nawuri data, there are fifteen instances in which a phonetically labialized consonant is transcribed before a round vowel. All fifteen cases involve one of the four consonants k^w , b^w , p^w , and f^w before a non-high round vowel (o or ɔ). In eight out of the fifteen cases the round conditioning vowel is in turn immediately followed by another consonant. In all eight of these instances, this following consonant is one of the alveolar segments t , r , or l .

Of further interest is the fact that a number of other Ghanaian languages from several language families exhibit tendencies for contextual labialization to be favored in these same kinds of environments. Allophonic labialization of consonants is favored in some way before round vowels of lower tongue height¹⁵ in Chumburung, Hanga, Kasem, Konkomba, and Adele.¹⁶ In Chumburung [Snider 1986], contextual labialization is said to occur only before the vowel ɔ , which, in its usual phonetic realization, is the lowest of the four round vowels in the language [Snider 1984:9]. In the case of Hanga, Hunt [1981] describes several of the consonants in the language as having labialized allophones before non-high ("non-close" in his terminology) round vowels; allophonic labialization does not occur before high ("close") round vowels. All consonants in Kasem [Callow 1965] are allophonically rounded before round vowels. Two consonants however, k and η , are more strongly labialized before non-high ("open" in Callow's terminology) round vowels than before high ("close") ones. According to Steele and Weed [1966], thirteen of the twenty-one consonants in Konkomba may undergo contextual labialization before round vowels. All but four of these thirteen consonants have two labialized allophones, one of which is described as "labialised" and the other as "slightly labialised". While the precise distribution of these allophones is fairly complex and varies somewhat according to which consonant is involved, there is an overall tendency for the degree of labialization to be inversely correlated with

¹⁴A few of these may actually be $[\text{ɔ}]$.

¹⁵It is also interesting that parallel cases where *palatalization* is favored in some way before front vowels of lower tongue height have been reported, for example in Tampulma [Bergman, Gray & Gray 1969] and Hanga [Hunt 1981].

¹⁶A somewhat different pattern, in which the degree of contextual labialization of alveolar and alveo-palatal consonants is greater before $[\text{ɔ}]$ and $[\text{ɔ}]$ than before $[\text{ɔ}]$, $[\text{o}]$, and $[\text{u}]$ is reported in Basari [Abbott and Cox 1966:14].

the tongue height of the following conditioning vowel. Before [ɔ] (an allophone of /ɔ/), for example, which is phonetically the lowest round vocalic segment that occurs in the language, only the stronger of the two labialized allophones ever occurs. Only the “slightly labialised” forms, on the other hand, ever occur before the high back vowel /u/, and then only when it is lowered phonetically to [ɔ]. Before [u] (the other allphone of /u/), which is phonetically the highest round vowel segment occurring in the language, consonants are not reported to be labialized at all. In the case of Adele, Renate Kleiner informs me (personal communication) that her phonetic data show eight instances in which she has transcribed consonants with labialization before a mid round vowel (o or ɔ) and two instances where she has transcribed labialization before the high vowel ɔ. Before u, which is phonetically the highest of the four round vowels in the language, she has no examples where she has transcribed consonants as labialized.

Another point of partial similarity to the Nawuri pattern is found in Hanga, Kasem, Chumburung, and Basari, in that velar or labial consonants undergo contextual rounding more readily or more strongly than others. According to Hunt, only the consonants *k*, *p*, *b*, *g*, and *ŋ* may be allophonically labialized in Hanga. While all consonants are allophonically rounded before round vowels in Kasem, it is only the velar consonants *k* and *ŋ* which are reported to have more strongly labialized allophones (which, as already stated, occur before non-high round vowels). In the case of Chumburung, Snider [1986:54] posits an allophonic rounding rule that applies only to non-coronal consonants, although he later adds that “while [+coronal] consonants in general aren't rounded before [ɔ] there is a tendency for some of those which are palatal (i.e. [+high]) to have a degree of rounding. This is most pronounced in the case of /ç/.” While contextual labialization in Basari [Abbott and Cox 1966] may occur with all consonants except labio-velars, *y*, and *l*, “the consonants which show the greatest degree of labialisation are the bilabials and velars.”

A final point of similarity is found in Konkomba, in which contextual labialization also appears to depend on the identity of the consonant that follows the conditioning round vowel. With few exceptions, allophonic labialization (whether weak or strong) may occur on the initial consonant of a closed syllable only if the consonant which closes that syllable is one of the consonants *b*, *m*, *n*, *r*, or *l*.¹⁷ While this pattern is not completely identical to the one I described for Nawuri (in that, first, the consonant following the conditioning vowel is relevant only when it occurs in the same syllable and, second, a following labial consonant as well as a following alveolar consonant may be conducive to labialization) it is similar enough to be noteworthy.

¹⁷In the actual words employed by Steele and Weed, the consonant which closes the syllable must be “other than a velar”. Elsewhere (p.3) they list the following consonants as occurring syllable-finally: *b*, *k*, *r*, *l*, *m*, *n*, and *ŋ*.

Where natural assimilatory processes are at work, there is ordinarily nothing unusual about languages exhibiting similar patterns of allophonic variation. What makes these particular tendencies somewhat surprising, however, is that there is no obvious articulatory motivation for them. It is difficult to imagine, for example, what articulatory factors might lead to consonants rounding more readily before non-high round vowels than before high ones. (If anything, we might have expected consonants to be more labialized before high round vowels, since these generally involve tighter lip-rounding than mid vowels.) The tendency for non-coronal consonants to undergo contextual labialization more readily than coronal ones is also difficult to understand in purely articulatory terms. Perhaps most puzzling of all, from an articulatory standpoint, are the patterns in Nawuri and Konkomba in which the degree of labialization appears to depend on the identity of the consonant following the conditioning round vowel.

While one cannot rule out the possibility that natural articulatory-based explanations could in fact be found for these tendencies, it is also quite possible that they might be more profitably explained in terms of acoustic factors. I am suggesting, in other words, that (in Nawuri and perhaps in the other languages mentioned as well) consonants are not necessarily articulated with a greater degree of lip-rounding in the environments cited. Rather, acoustic factors are at work to give greater perceptual prominence to labialization in these environments. As a somewhat rough and tentative example of the kind of acoustic factors I have in mind, it is reasonable to suppose that a major perceptual cue to the labialization of a consonant is a rising second formant transition in the following vowel. Presumably, the perceptual salience of the labialization would increase in proportion to the slope of this formant. The tendency in Nawuri for contextual labialization to be particularly salient where the conditioning round vowel is non-high and followed by an alveolar consonant might then be explained as being due to the high F_2 locus of the alveolar point of articulation and the lower F_2 value for non-high vowels. This combination would lead to a particularly steep second formant slope in the vowel following the labialized consonant, i.e. the conditioning vowel. The high F_2 locus of alveolar consonants might also help to explain why alveolar consonants are, in several of the languages, less likely to be heard with clearly audible labialization: since F_2 starts off high to begin with, the prospects of it rising significantly during the following vowel are reduced.

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