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# The Phonology of Intonation in Hausa

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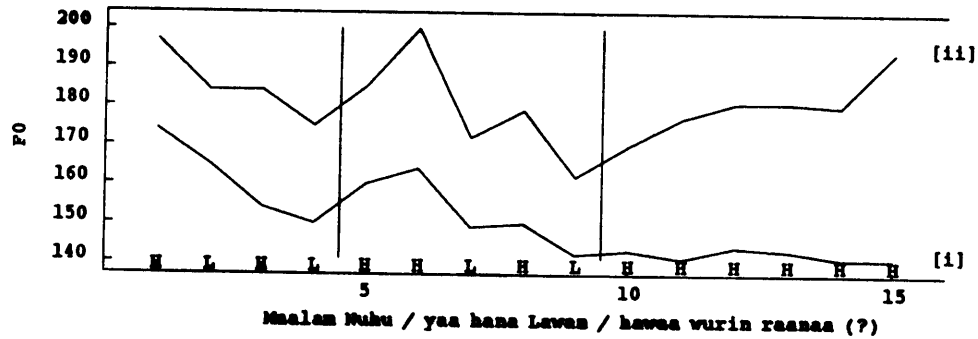
## Introduction<sup>1</sup>

Intonation is a relatively unstudied phenomenon, especially in lexical tone languages, but the intonational system of Hausa, a Chadic language of Nigeria, has received enough attention in the literature to suggest some very interesting generalizations that a descriptive framework for intonation would seek to capture.<sup>2</sup> In Leben, Inkelas, and Cobler 1986 we showed that these generalizations could be accounted for by a phonological model with an autosegmental register tier parallel to but distinct from the tier on which lexical tonal contrasts are represented. In the present paper, we refine our earlier account on the basis of newly collected data and we show that our phonological representations help to explain relationships that are seemingly beyond the expressive power of the sorts of phonetic implementation rules proposed for other languages by Liberman and Pierrehumbert 1984 and Pierrehumbert and Beckman 1986. This, we think, clarifies the division of labor between phonological rules and phonetic implementation rules in Hausa.

## Yes/No Question intonation

We can distinguish several types of intonational processes in Hausa, all of which are instantiated in yes/no questions. First, there is Global Raising, which applies essentially to every tone in a yes/no question, raising it above the value it would have if it were in a declarative. Global Raising is illustrated in the graph in (1). This graph represents an average of ten tokens of a declarative and a corresponding yes/no question uttered by a native speaker.<sup>3</sup>

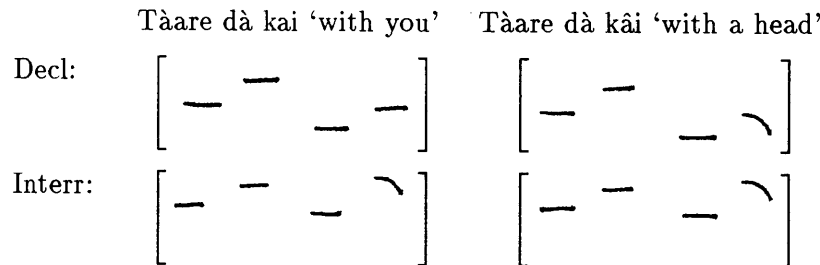
(1)



Since Global Raising does not appear to interact with the phonology or syntax of an utterance at all, we suppose that it is accomplished by a relatively low-level phonetic implementation rule.

Next, there are purely local processes, e.g. the addition of a Low or High to the tier of lexical tones. An example is given in (2). A Low boundary tone is added by some speakers at the end of yes/no questions. We know that this Low boundary tone is added to the lexical tier because it behaves just like Lows already present in the lexical tier. As shown in the diagrams below, in declaratives the word *kai* ‘you’ contrasts lexically with *kâi* ‘head’. The one on the left has a High, while the one on the right has a fall, a High-Low sequence. When question intonation introduces a lexical Low, this Low makes the High of *kai* ‘you’ indistinguishable from the High-Low of *kâi* ‘head’.

(2)



Apart from global and local effects, yes/no questions also exhibit an intermediate type of effect that provides motivation for adding a new tonal tier—a register tier—to the phonological representation. In the spirit of proposals by Yip 1980 and Hyman 1986, we posit that tones on the register tier are linked to lexical tones and by virtue of this linking alter the realizations of these tones. The phenomena that motivate the register tier are summarized here and discussed at greater length below.

As Hausa yes/no questions are typically described, they combine three factors. The first is the total or partial suspension of downdrift. Downdrift is the phonologically conditioned process whereby a Low tone is lowered below the level of the previous Low, inducing a downward register shift which persists across the phrase. In our framework, this downward shift results from a Low tone on the register tier. This process is normally called downdrift in the literature on African tone languages, but has been termed ‘downstep’ in Pierrehumbert’s work on English (Pierrehumbert

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1980) and 'catathesis' in Poser's work on Japanese (Poser 1984). The suspension of downdrift means, simply, that downward register shift does not take place.

The second aspect of Hausa yes/no question intonation is the change of a phrase-final lexical High to extra-High. The third is the realization of a following boundary Low as raised Low.

The formalization of the notions 'extra-High' and 'raised Low' is straightforward in our framework. A register High tone associated with lexical High will make it extra-High, and the same tone associated with lexical Low will raise the lexical Low. We will show later that the presence of this register High also explains the suspension of downdrift.

## Intonational phrases

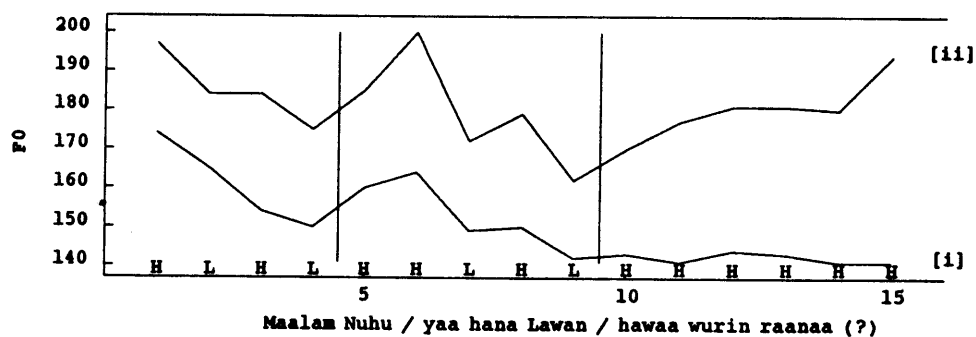
First, we need to look at an important condition on a number of phonetic processes that govern the realization of Hausa tones: these processes apply within phrases but not across phrase boundaries. The phrases we refer to here are largely syntactically determined—e.g. noun phrases, verb phrases, adverbial phrases—but are not necessarily coextensive with syntactic constituents. Moreover, the way a sentence is parsed into intonational phrases may vary. We have not made a careful study of the syntax of phrasing in Hausa, but we believe that Hausa intonational phrases are comparable to the major phrases Poser 1984 discusses for Japanese and the intonational phrases which have been proposed as a domain for English intonation rules (see e.g. Bing 1979, Selkirk 1984, and Nespor and Vogel 1986, and the references therein).

In Hausa, intonational phrases are not necessarily marked phonologically by pause. We have not investigated whether they are marked by any segmental cues. But we will demonstrate that they are marked phonetically by the inability of certain intonational effects to cross over them.

Low Raising is the assimilatory process that moves the F<sub>0</sub> value of a Low tone upward in the environment of High tones.<sup>4</sup> The amount of raising is variable, but it is not uncommon for Low Raising to cause the Low in a High-Low-High sequence to have a fundamental frequency higher than that of the following High. (The following High is lower than the preceding High by virtue of downdrift.)

The application of Low Raising is illustrated in the graph in (1), reproduced below. In the declarative, the F<sub>0</sub> value of the first Low tone is intermediate between that of the two surrounding Highs.

(3)



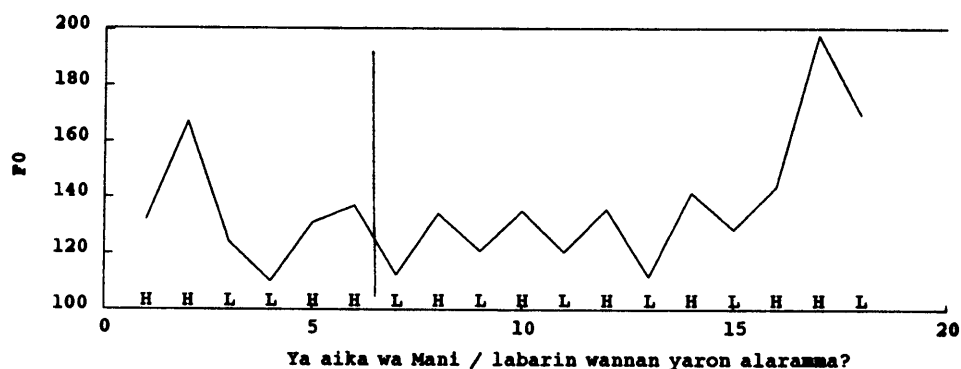
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Another rule sensitive to phrase boundaries is High Raising, which causes a slight rise across a string of High tones before Low in the same phrase. High Raising is also illustrated in the graph in (3), applying to the High-High-Low sequence beginning the second phrase in both curves. If there is a phrase boundary before the conditioning Low, High Raising will not apply. The amount by which a High is raised is variable, and, like Low Raising, High Raising is an optional rule.

A third process sensitive to phrase boundaries is downdrift, which we take up in detail in the next section. Downdrift triggers the lowering of a Low tone and any following High. Because of the variability in the F0 of Low tones (due to optional Low Raising), the effects of downdrift are often noticed most strikingly on the first High in the lowered register. Furthermore, the effect of downdrift persists. If downdrift applies again within a phrase, the register is lowered even further.

A final instance of the effect of phrases on intonation is illustrated in the graph in (4). We stated earlier that downdrift is suspended in questions. But in fact downdrift is suspended only in the final phrase. We see in (4) that while there is normal downdrift in the first phrase, the second phrase exhibits no downdrift at all.<sup>5</sup>

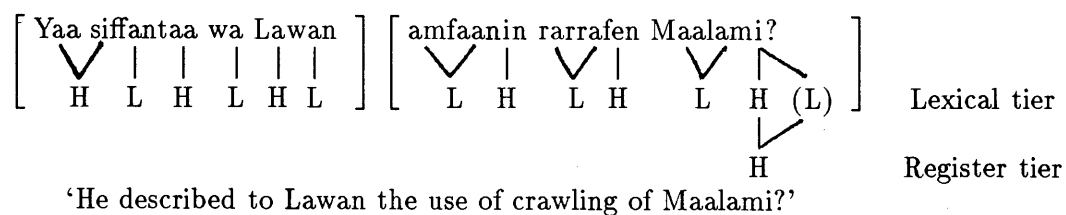
(4)



## Phonological Representation of Intonation

We now turn to the formalization of the phonological effects we have noted. As we have said, we propose to account for raising at the end of questions by the addition of a second tonal tier. This register tier contains a High tone which is associated with the final lexical High in the question, as in (5).

(5)



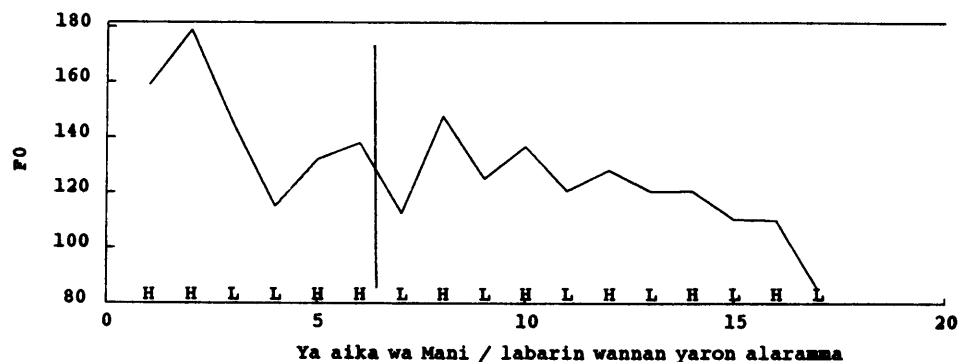
Unlike a boundary tone, which is just an addition to a sequence of lexical tones, a register tone *shifts* the register, so that it affects not only the tone it is associated with but all the remaining tones in the phrase as well. The effect of the register

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tone in (5) is to reset the register *upward*, so that the rightmost High becomes 'extra-High'; if the speaker chooses to add a Low boundary tone, the Low becomes raised as well.

As the graph in (4) illustrates, raising is not restricted to the rightmost High. One difference between the question in (4) and the corresponding declarative, represented below in (6), is that there is no downdrift in the final phrase of the question. In other words, all of the High tones in the final phrase of the question are raised above the level at which they are realized in the declarative.

(6)



We can account for raising in the final phrase by positing that a phonological rule spreads the High register tone of the final syllable back onto the preceding High tone or tones in the phrase.

(7) Register Tone Spreading (optional; iterative)

Lexical tier:	H	L	H	→	H	L	H
Register tier:			H		H	H	

Our task is now to explain the correlation between the backward spreading of register High and the absence of downdrift on the syllable to which the High spreads. We can accomplish this simply by reasoning that if Hausa has a High-toned register, then it must also have a Low-toned register. The manifestation of a register Low is, simply, downdrift.

Above we described downdrift as the process whereby a Low tone causes the register to be lowered for all following tones, Low and High. This is expressed in the downdrift rule in (8), which shows the association of a Low tone on the register tier with a Low tone on the lexical tier. This Low Register tone then links to the following lexical High by rule (9).

(8) Downdrift:

L	Lexical tier
⋮	
L	Register tier

(9) Register L Attachment:

L	H	Lexical tier
	/	
L		Register tier

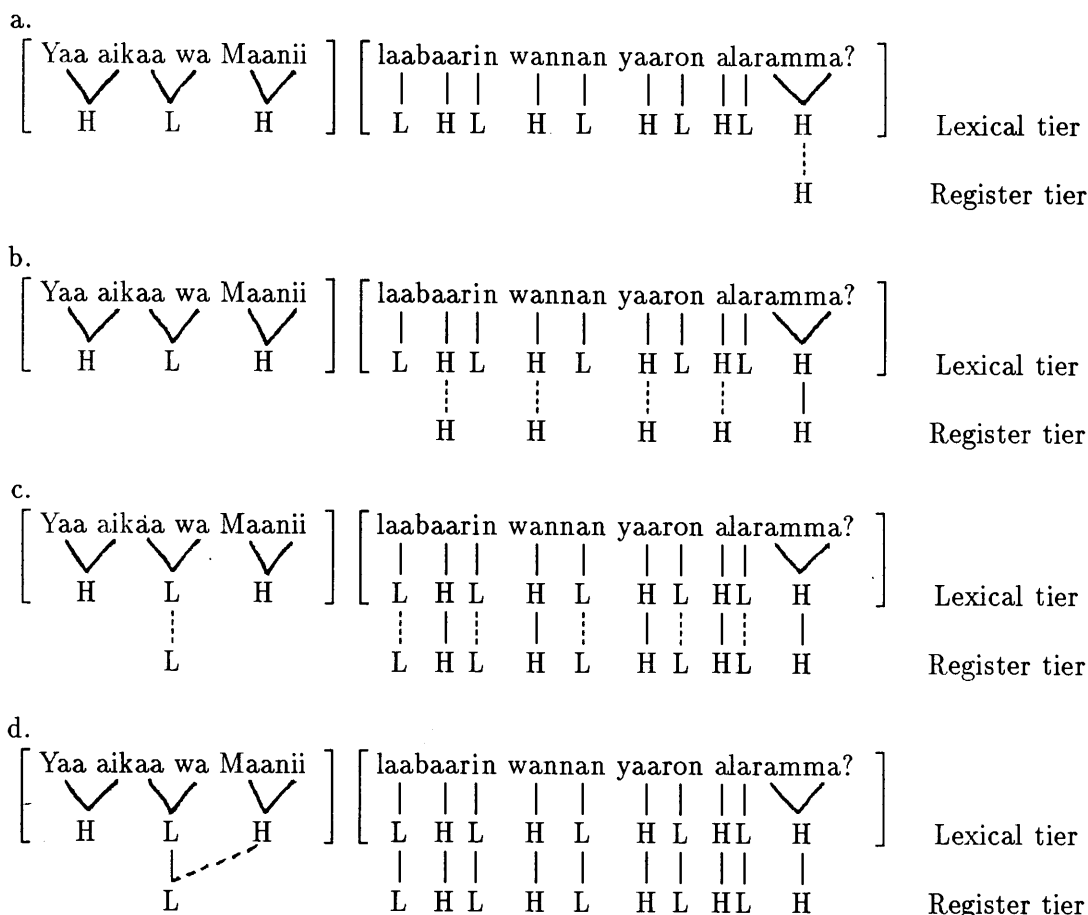
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(8) says in effect that downdrift is caused by a lexical Low tone. (9) says in effect that downdrift pulls down the register on which a following High tone is uttered.

We may now explain why the second High tone in the final phrase of (4) is not downdrifted in relation to the first High: it has acquired a High register tone by leftward spreading, making rule (9) inapplicable.

The sample derivation in (10) illustrates how the rules operate. (10) represents the declarative utterance *Yaa aikaa wa Maanii laabaarin wannan yaaron alamma* 'He sent Mani news of this boy of the alamma'. (10a) shows the attachment of a High register at the end of the final phrase of the question; within the final phrase, the High spreads backward by Register Tone Spreading in (10b). (10c) shows the application of Downdrift, which attaches a register Low to each lexical Low. Register Low Attachment links this register Low to a following lexical High in (10d), when that High tone is in the same phrase and not already linked to a register High.

(10)



Our account also makes certain predictions about differences between downdrift within phrases and across phrases. Within a phrase, downdrift is obligatory, as provided by rule (9). But when High occurs phrase-initially, it will not link to the final Low of the preceding phrase: (9) does not apply across phrase boundaries. This does not however mean that phrase-initial High will not be downdrifted in

relation to the High of a preceding phrase. Any Low tone in a preceding phrase will set up a Low Register tone, by (8). If that Low tone is phrase-final, and if the next phrase begins with a High tone, it is perfectly possible for the phrase-initial High tone to be uttered on the register set up by that Low tone. But it is not necessary. Since phrase-initial High is not actually linked to a Register Low, we might expect that it is somewhat free to vary. This turns out to be correct. We looked at High-Low-High sequences in eight declaratives, disregarding cases where the second High was raised for emphasis. When these sequences were wholly contained within one intonational phrase, the second High was lower than the first 98% of the time (for 140 instances). When the second High began a new phrase, it was lower than the first only 68% of the time (for 150 instances).

### Complementarity

If raising is carried out by register High and lowering is carried out by register Low, then on our account it should be impossible for them to co-occur. Note that this is *not* a logically necessary fact. For instance, in Global Raising, illustrated in (1), downdrift does apply. This is because Global Raising is not achieved by a register tone. In the final phrase of yes/no questions, on the other hand, downdrift and raising are in complementary distribution. Our account predicts this fact.

Along with explaining complementarity, our phonological representation provides a close first approximation to the phonetic facts.

If we interpret each register tone literally as setting up a new register for subsequent tones, and if we interpret High register as the instruction to go up in F<sub>0</sub> by a certain amount and Low register as the instruction to go down by a similar amount, then we should expect that in a sequence of alternating H and L register tones, each successive register High tone will cancel out the lowering effect of the preceding Low tone. Thus for the example sketched in part (d) of the derivation in (10), we should expect that the value of High should remain relatively constant across the phrase, despite intervening Low tones.

Now in fact the final High tone *is* raised, but this is due to an independent effect, raising a *phrase-final* High-toned syllable linked to a register High tone essentially to the top of the speaker's register. Apart from this, our data show that non-final Highs which are linked to register Highs remain quite constant, which is what we predict.<sup>6</sup>

In addition to downdrift and raising in yes/no questions, the register tier has other uses in Hausa. In particular, a register High will be used to account for other instances of raising. We will give two examples.

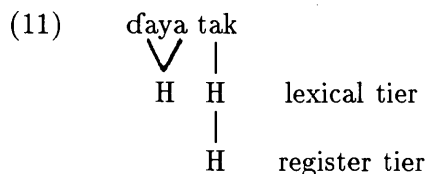
The first is the case of ideophones. Certain emphatic particles are always pronounced with an extra-High tone. In (11), we see the example *daya tak* 'one only.' Associated with each of the three syllables is a lexical High tone, and associated with the ideophone *tak* is a register High. Since this register High does not spread leftward in examples like this one, we must stipulate that Register High Spreading applies only in questions. In order to formulate a correct account of the behavior of ideophones, we must first discuss the Obligatory Contour Principle.

We propose that the Obligatory Contour Principle (Leben 1978) groups identical High tone sequences into single High tones, preserving existing links. The basis for

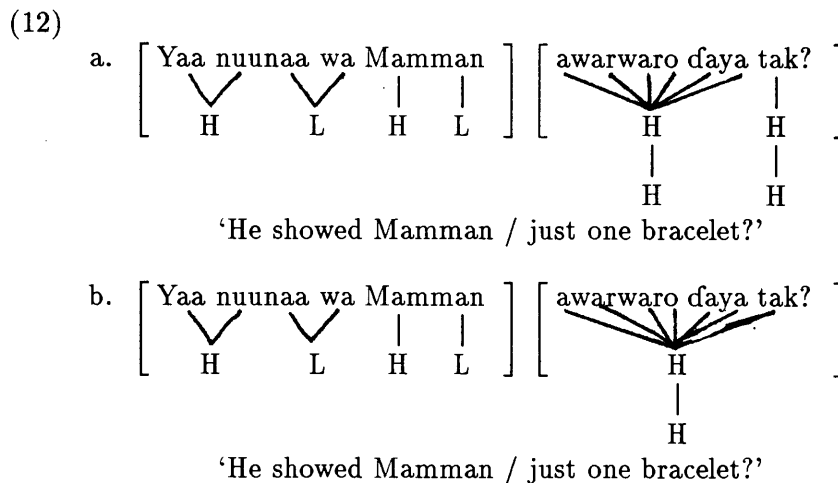


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this proposal is the fact that in general the rules of intonation do not require a distinction between such lexical tonal representations as HHHHH and H. The OCP yields the automatic prediction that if a High register tone is attached to a linked lexical High, all of the syllables in that sequence will be raised. This prediction is borne out by the facts of emphasis, discussed at the end of this section. The OCP also permits us to explain the behavior of ideophones in declaratives. As exemplified in (11), the lexical HH sequence of *ɗaya* is represented as a doubly linked High on the lexical tier. If we posit that the OCP requires identity of tones rather than non-distinctness, this will entail that the lexical High of *ɗaya* will not merge with the lexical High of the ideophone *tak*, since the latter is lexically linked with a High register tone while the former is not.



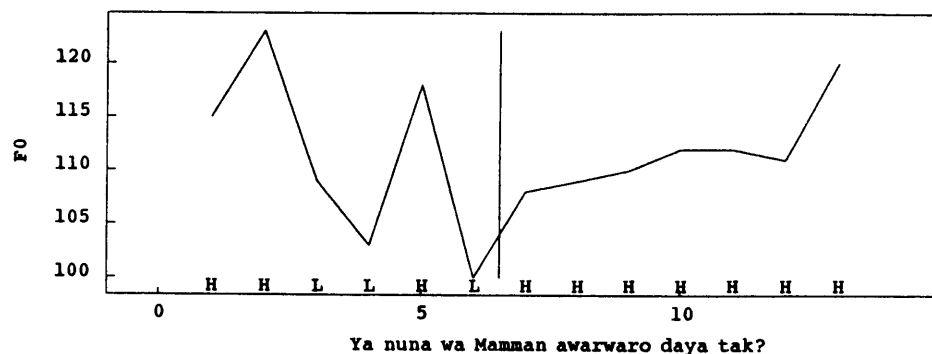
If *ɗaya tak* formed the last part of a yes/no question, we might expect it to be represented as in (12a). But for reasons that we will see later in the discussion of emphasis, we know independently that the Obligatory Contour Principle will simplify this representation as illustrated in (12b).



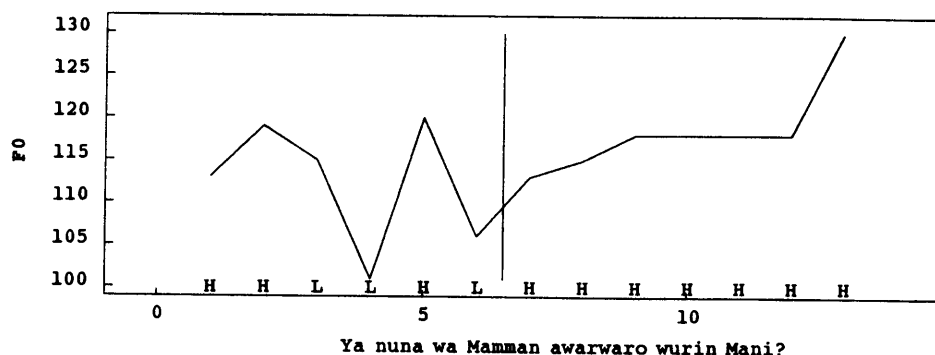
Consider now the corresponding yes/no question in which the ideophone *tak* is replaced by a normal lexically High-toned monosyllable. A register H question marker would be linked to the final lexical H, which by virtue of the OCP is itself linked to each of the syllables in the final phrase. The resulting representation is tonally identical with the (b) representation above.<sup>7</sup> So our analysis predicts the neutralization of ideophones in the context of yes/no questions. This prediction is borne out by our data, and illustrated in graphs (13) and (14). (13) represents a question ending in a High ideophone; (14) represents a question ending in normal lexical High. Note the similarity of the two curves.

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(13)



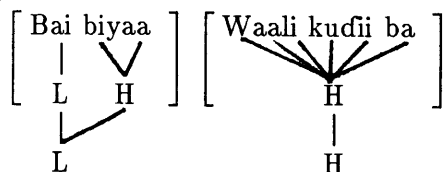
(14)



Register tones also account for some of the facts of emphasis in Hausa. Emphasis involves raising the first High tone of the emphasized word, which we can account for by adding a register High to the lexical High tone.

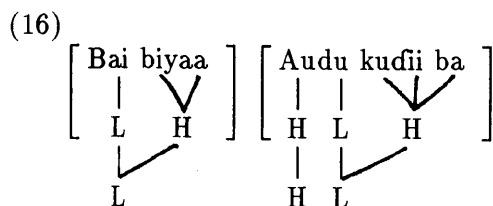
This will predict that in the absence of intervening lexical Lows, once a register High has shifted the register upward the register should remain elevated until the end of the phrase. This prediction appears to be correct. Consider the sentence in (15).

(15)



This means 'He didn't pay *Waali* any money', with emphasis on the word *Waali*. To emphasize *Waali*, which is lexically all-High, a register High is associated with the first (and only) lexical High in the phrase, producing an 'extra-High'. Since there are no lexical Lows to condition downdrift, the 'extra-High' is pronounced not just on *Waali* but on all the following Highs in the phrase as well. In eliciting data on this type of sentence, we explicitly asked speakers to lower the tone to a non-raised register after the emphasized word. They uniformly rejected this. By contrast, in an utterance like (16),

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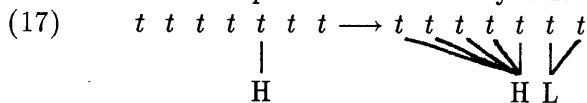
speakers are able to lower the register back to normal after the emphasized word *Audu*. This is exactly what we would expect, since the lexical Low of *Audu* divides the emphasized High tone of the preceding syllable from the High-toned sequence following and occasions the insertion of a register Low which lowers the remainder of the sentence.

Finally, if *two* words in an all High-sequence are emphasized, only the first exhibits a raised register. For example, the tonal realization of the sentence *Bai biya Waali kudii ba* in which both *Waali* and *kudii* are emphasized is indistinguishable from the sentence illustrated above, where only *Waali* is emphasized. This is exactly what we would expect under the version of the OCP proposed above. The two emphasized words would each have their lexical High linked to a register High, satisfying the identity requirement which would cause them to be converted to the same representation given for the preceding example.

### The Role of Phonetic Implementation Rules

A potentially important consequence of our proposal is that it sheds light on an issue raised in recent work by Pierrehumbert and Beckman 1986.

Pierrehumbert and Beckman argue that in Japanese, the rules of intonation apply to representations with very sparse tonal markings, in contrast to a more standard autosegmental account in which each tone-bearing unit would be linked to some tone before the rules of intonation applied. An example of the latter kind is the detailed analysis of Poser 1984. Poser posits underlying representations for lexical items in which at most one syllable is lexically linked to a tone. This syllable, linked to a High tone, is what is traditionally referred to as the accented syllable. Words are grouped into accentual phrases, with at most one linked High tone per phrase. A phonological rule of Spreading spreads this High leftward onto toneless syllables.<sup>8</sup> Post-accentual tone-bearing units acquire Low tones. The essentials of this account are depicted schematically below:



The derived representation on the right, augmented by the insertion of boundary tones, provides the input to the rules of intonation.

Pierrehumbert and Beckman propose instead that an underspecified representation like that on the left in (17), augmented with special phrase tones and boundary tones, is the input to a set of phonetic implementation rules. They posit that in an accentual phrase, the only possible linked tones are the lexical High associated with the first mora of an accented syllable, a phrasal High associated with the second sonorant mora in the phrase, and one or more boundary tones. Each tone represents

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an F0 target, and the F0 contour is derived by interpolating between the targets. Thus, the rules of phrase phonology would provide for a derivation like the one represented schematically below (to simplify matters somewhat we leave out the first sonorant mora, which is sometimes High and sometimes Low):

$$(18) \quad \begin{array}{cccccccc} t & t & t & t & t & t & t & t \\ & & & & | & & | & | & | \\ & & & & H & & H & H^* & L & \% \end{array}$$

In the output, the first linked High represents a phrase tone linked to the second sonorant mora of the phrase. Subsequent phonetic implementation rules assign values to the unlinked tone-bearing units by interpolating between the F0 targets corresponding to these phonological tones.

Pierrehumbert and Beckman argue their account on the basis of the fact that the phonetic realizations of Japanese phrases do not match the level H sequences that would be produced if H spreading applied. They observe that the phrasal High (H) is lower in F0 than the accent High (H\*) when all other factors are equal and that their data (and Poser's) are quite consistent with the gradual transitions that one would expect from the interpolation of F0 values across tone-bearing units unspecified for tone. Thus, they reject the intermediate stage that Poser's Spreading rule would yield.

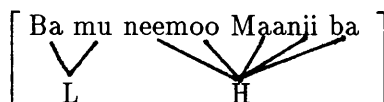
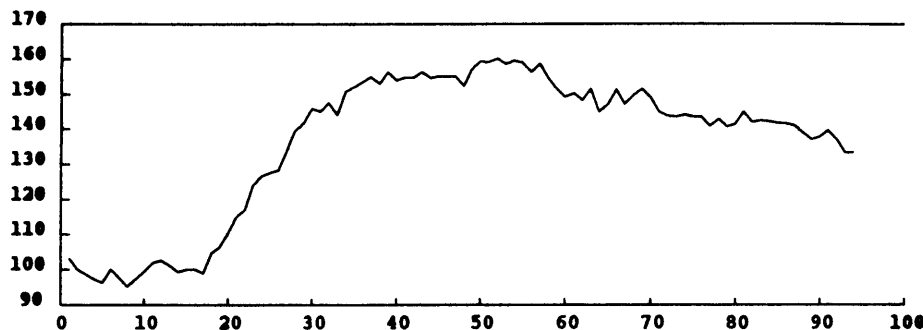
This is an interesting proposal, but one may question the generality of the theoretical conclusions that might be drawn from it. If a lexical tone language were found to exhibit similar intonational phenomena to Japanese and yet to possess phonological representations at some level that were fully specified tonally, how would Pierrehumbert and Beckman account for the similarities? Would they convert the fully specified tonal representations into underspecified ones like those that serve as inputs to their Japanese implementation rules? If not, then whatever phonetic rules mapped from fully specified phonological tones onto F0 contours for this hypothetical tone language could presumably work just as well for Japanese, with fully specified tones. If Pierrehumbert and Beckman did choose to convert fully specified representations in a lexical tone language into partially specified ones resembling those of Japanese, then the elegance achieved by avoiding the formulation of a phonological rule of Spreading for Japanese would be counterbalanced by the need to make the opposite change in the lexical tone language.

We believe that Hausa fits the hypothetical description just given. In particular, the gradualness of the transition from a Low tone to the last High tone in a sequence like LHHHL in normal Hausa phrases looks like a reasonable candidate for interpolation between the first Low and last High in the sequence, as Pierrehumbert and Beckman have proposed for Japanese. But we can be fairly certain that each of the tones in a LHHHL sequence is present in the lexical representation for Hausa. For one thing, the distribution of underlying tonal contrasts is sufficiently free that it can be argued that each syllable is specified lexically for a tone. Secondly, even if we find reason to assume that some syllables are underlyingly unspecified for tone, there are phonetic facts that argue that these syllables bear tones at the level at which the rules of Hausa intonation interpret them. In contrast to normal utterances, with their more or less gradual transitions in F0, Hausa has utterances with what might be called 'exaggerated' intonation. In (19) we show the F0 contour for one utterance of the sentence *Ba mu neemoo Maanii ba* 'We didn't go and look for

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Mani'. The exaggerated intonation adds a connotation of finality to the utterance: 'We didn't go and look for Mani, and that's all there is to it.' Phonetically, this exaggerated intonation is marked by abrupt F0 transitions between syllables on different tones, as illustrated below:

(19)



We thus take it that the fully specified lexical tones of Hausa are input to the rules of intonation, and that any gradualness in F0 transitions is the result of smoothing the abrupt transitions predicted by the lexical tones. But if the theory requires these operations in Hausa, then it seems pointless to attempt to rule out this possibility for Japanese.

Moreover, as we have seen, Hausa downdrift and the raising in the final phrase in questions are in complementary distribution. This constitutes positive evidence for our phonological representation for Hausa intonation. We cannot see how this result could be captured (except of course by stipulation) in an analysis like Pierrehumbert and Beckman's, with a relatively impoverished phonology and a richer system of phonetic implementation rules. Indeed, we showed earlier in (1) that Global Raising, which we assume on any account would be handled purely by phonetic implementation rules, is simply added incrementally to the F0 contour, with all of the downdrifts, upsteps, etc., which that contour may already possess by virtue of its phonological content. Thus, it would be natural to expect phonetic implementation *not* to yield the sorts of complementarity effects we have captured on our phonological account.

## Conclusions

We have shown how a phonological register tier accounts for the distribution and, to some extent, the phonetics of the intonational phenomena of downdrift, question intonation, and emphatic raising in Hausa. By considering phonetic and phonological data, we have argued that the program of Pierrehumbert and Beckman 1986 to simplify phonological representations by expanding the role of phonetic implementation rules would lead to a otherwise unnecessary operation in Hausa to convert representations in which each tone-bearing unit is tonally linked into representa-

tions in which only some of them are tonally linked. In our account, the Obligatory Contour Principle preserves what appears to be the valid part of Pierrehumbert and Beckman's insight that only a small number of phonological tones are needed to specify the F0 targets for phonetic rules.

Finally, the different behaviors of Global Raising and raising in the final phrase of questions suggest a natural dichotomy between the phonological and phonetic representations of pitch information. The phonological representations, which deal with tones, have a limited number of ways of combining tonal values. For example, given a register tier specification of High tone and a rule inserting a Low tone on the register tier, the insertion may be carried out only by juxtaposition to the High tone already specified or by replacement of that High tone. A phonological Low could not, for example, be simply superimposed a High tone. This is why register High and register Low are in complementary distribution in Hausa. Phonetic representations, on the other hand, interpret tones in terms of physical parameters. If we maintain that the phonetic assignment of a given F0 value to a tone need not deter other phonetic rules from assigning it additional F0 increments, which are in effect superimposed on pre-existing values, then we can explain why the phonetic phenomenon of Global Raising in Hausa is not inconsistent with the application of downdrift, while the phonological raising in the final phrase of questions is in complementary distribution with downdrift.

### Footnotes

- <sup>1</sup>The research reported on here was supported by a grant from NSF, #BNS 85-11690. We also gratefully acknowledge the assistance of Anthony Davis and George Papcun in producing the statistics cited in the paper.
- <sup>2</sup>The phonetic and phonological studies of Hausa intonation that we have consulted are: Wangler 1963, Meyers 1976, Silverstein 1976, Hunter 1979, Miller and Tench 1980, 1982, Newman and Newman 1981, and Lindau 1986.
- <sup>3</sup>These, along with the rest of our data, were recorded in Nigeria and analyzed at Stanford. What is depicted in all of the graphs presented in this paper is one point per syllable: the peak of High syllables and the valley of Low syllables.
- <sup>4</sup>This account presupposes a rule applying before Low Raising which sets a value for Low. Such a rule has in fact been proposed for Hausa by Meyers 1976. As an alternative, one might seek to express 'Low Raising' instead as a unitary implementation process for Low tones which takes neighboring tones into account.
- <sup>5</sup>Note that the final syllable of *alaramma* is marked as lexically Low in the declarative but lexically High in the question. Certain speakers, including the one who produced these utterances, have a rule which takes a question-final lexical Low to High after a High tone. For these speakers, the difference between question-final High-Low and High-High is neutralized.
- <sup>6</sup>To test the significance of the suspension of downdrift in questions, we performed a test for linear trend developed by Meddiss 1984, using the ranks of the F0 values for each High-toned syllable in the final phrase other than the rightmost High-toned syllable, which undergoes extra raising in questions. We tested declarative and interrogative versions of two different sentences. The test showed that the downward

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trend across High syllables was significant at the .05 level for each declarative, whereas in the interrogatives a level trend proved to be significant (also at the .05 level).

<sup>7</sup>As we mentioned earlier in connection with yes/no questions, a phrase-final register High linked to lexical High will be realized near the top of the speaker's range. This effect is evident in each question depicted graphically in the paper.

<sup>8</sup>An additional fact is that Low tone is assigned to an initial light syllable. Otherwise the initial syllable is High.

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