OSU Working Papers in Linguistics 45 (36-55)

Final Lowering in Kipare*

Rebecca Herman
rherman@ling.ohio-state.edu

Abstract: Data from Kipare, a Bantu language which has both lexical tone and final lowering, were examined to determine the optimal model of final lowering in a tone language. The models evaluated are the register model, in which final lowering is accounted for by manipulating tone categories, and the boundary tone model, in which final lowering is accounted for by a separate tone on the same tier as lexical tones but associated to a higher prosodic position. Aspects of final lowering in Kipare examined in this study include which lexical tone categories show final lowering, whether the lowered tones coincide with tones from another lexical tone category, the locality of the effect, the relation of contrasting utterance types to utterance types showing final lowering, and what the domain of final lowering is.

1. Introduction

In many languages, fundamental frequency decreases utterance-finally. For example, final lowering is documented in Japanese by Pierrehumbert and Beckman (1988), in English by Liberman and Pierrehumbert (1984), in Dutch by Gussenhoven and Rietveld (1988), in Danish by Thorsen (1985), in Yoruba by Laniran (1992), and in Kikuyu by Clements and Ford (1981). Ladefoged (1982) generalizes that "In nearly all languages the completion of a grammatical unit such as a normal sentence is signaled by a falling pitch."

In tone languages, tone functions contrastively. Tonal categories such as high (H) and low (L) must be posited to account for the contrasts. In such cases, it is possible to analyze a decrease in fundamental frequency utterance finally as a change from one tonal category to a lower one. Such analyses are prevalent in the literature on tonal phenomena in African languages.

For example, Clements and Ford (1981) describe "automatic downstep" in Kikuyu, where the last low tone (or low tone sequence) of a noninterrogative sentence is downstepped. They analyze this as a rule inserting a downstep. The rule is formulated as: $\emptyset$ --> ! / __ L_q (H_q)]$_S$, where "q" stand for "any number of." A further rule suspends this effect in positively oriented questions by deleting the downstep.

In a related case, Elugbe (1977) describes final low raising in statements and lack thereof in questions in Isoko and Urhobo. This is a counterexample to Ladefoged's generalization about falling pitch signaling "a normal sentence." In these languages, it is questions which are distinguished by final lowering. No

* The bulk of funding for this project was supplied by the Linguistics Department at the Ohio State University. The paper was completed with support from an NSF Graduate Fellowship. I would like to thank Frida Tungaraza for her generosity with her time and for her tireless, good-humored work. This paper would not have been possible without her. Thanks also to M. Beckman, K. Johnson, S.-A. Jun, and D. Odden for guidance with this project. I am very grateful to C. McDougall for support and help. Finally, thanks to S. Jannedy and J. Venditti for technical assistance in the Lab.

matter what the function of final lowering, though, it is still analyzed as a change to a lower tone category. Thus, questions are analyzed with a final floating low which causes highs to fall but merges with low.

Roberts (1992) describes phrase-final lowering in Sukuma whereby a high tone is lowered to extra-low phrase-finally. This is analyzed as a rule changing the category H phrase-finally to the category XL.

The question is whether analyses such as those just described, which manipulate phonological tones, provide the optimal account of final lowering. Such analyses use rules like H --> !H / __# and !H --> L / __#. Based on evidence from contour tones, register shifts, "key raising," and natural classes of tones, it has been argued (Clements (1981), Inkelas and Leben (1990), and Snider and van der Hulst (1993)) that the tonal categories in such rules should be reinterpreted. Rather than indivisible entities, the categories may be defined in terms of feature combinations in the register model. In the register model, there are two tiers of tones, the pitch and the register tones. The representations of various tones in the register model are shown in Table 1.

	H	!H	L	!L
register tier	h	l	h	l
primary tier	H	H	L	L

Table 1. The representations of tones in the register model.

Assume a language in which H, !H, and L are each lowered to the next category down in final position. In such a system, the lowering of H to !H utterance-finally would involve changing an underlying register h to register l. The lowering of !H to L utterance-finally would involve changing an underlying primary H to primary L and an underlying register l to register h. And the lowering of L to !L would involve changing register h to register l. Although an account of final lowering is possible using such a system, it seems problematic, since a single phenomenon is analyzed in a non-uniform way.

The predictions of the register model for final lowering in a system in which each tone in final position lowers to the next tone category down are:

(i) The fundamental frequency values of a tone in final position should coincide with the fundamental frequency values of the next lower tone in medial position (assuming they are preceded by the same tonal sequence). For example, the values of a H tone finally should coincide with the values of a !H medially, all else being equal, since they have the same representation. This is schematized in (1), where (a) and (b) are predicted to be identical.

(1) (a) ... /H/ #
(b) .../!H/ ...

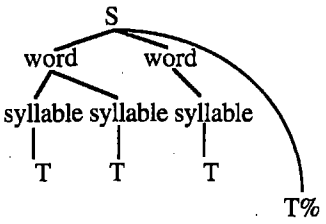
(ii) Final lowering should affect only the final tone-bearing unit, since only the final tone-bearing unit changes its representation. Alternatively, the change could spread to previous tone-bearing units, in which case it would be expected to affect each tone-bearing unit in the same way.

(iii) Contrasts between representations manifested via these tones should be localized in meaning to the domain to which they are associated.

An alternative analysis of final lowering, put forth by Pierrehumbert and Beckman (1988), uses boundary tones. In this model, delimitative peripheral tones

are attached directly to higher nodes, and are produced at about the same time as the initial or final lexical tones (p. 127). The boundary tones are linked to higher nodes in the prosodic tree, so they are available to affect the values of tones linked at lower levels. They are, in effect, local to the whole phrase since they are viewed as a property of the phrase (p. 75). This is schematized in (2), where T% represents the boundary tone and each T represents a lexical tone. S in this case represents a sentence, although Pierrehumbert and Beckman use the intonational phrase as the prosodic node to which boundary tones are attached.

(2)



The predictions of the boundary tone model of final lowering are:

(i) All tone categories should lower by the same amount when affected by a boundary tone. Medial !H and final H would not be expected to coincide, since they would have different representations. Rather, what might be expected is a relationship between medial and final tones of the same category. This relationship should then hold across all tonal categories. So perhaps what would be expected is a proportion of the sort "Final H is to an immediately preceding H as final !H is to an immediately preceding !H." For example, Silverman (1987) quantifies final lowering as the compression of the pitch range to be 30% narrower than the immediately preceding range. One potential problem with this prediction is that low tones are scaled differently than high tones (as discussed in Beckman and Pierrehumbert, 1992).

(ii) Final lowering has the greatest effect on extreme final tone-bearing units, but since it has scope over the entire utterance, it may also affect previous tone-bearing units to a lesser extent. Thus, the boundary tone "begins to show its influence on tones at some distance from the end" (p. 162).

(iii) Contrasts between representations manifested via different boundary tones should be contrasts in utterance types.

Kipare is a Bantu language which has both lexical tone and final lowering. It has been observed to have lowering of high tones to downstepped highs utterance-finally, lowering of downstepped high tones to lows utterance finally (Odden, 1986 a and b), and lowering of lows to a lower value utterance-finally (Odden, personal communication). Odden (1986a) notes that the rule lowering downstepped high tone to low tone must be ordered before the rule lowering high tones to downstepped high tones, implying that an underlying high tone does not lower to downstepped high tone utterance finally, then lower further to low tone. Rather, this implies that either lexical high lowers to downstepped high utterance finally, or else lexical downstepped high lowers to low utterance finally. However, downstepped high derived from lexical high does not lower further to become low. Thus Kipare provides a test case with which to evaluate the nature of final lowering in a tone language.

2. Methods

The speaker was a female Kipare speaker from the Same district, Kilimanjaro region, in Tanzania. She has lived in the United States for seven years. Her primary language is Kipare, but she also speaks English and KiSwahili.

Investigations of final lowering were conducted by first recording the subject reading sentences. Each sentence was recorded five times. The order in which the sentences were read was randomized (by shuffling 3-by-5 index cards on which the sentences were written) to control for position in the list of sentences. Recordings were done in a double-walled sound booth at the Ohio State University Linguistics Laboratory using a TEAC V-427C cassette deck and a head-mounted microphone. Then, the recordings were digitized and pitch traces were created using *Waves*™ (Entropic Research Laboratory, Inc., 1993) . The fundamental frequency was measured from the pitch traces in the center of each target vowel, as shown in Figure 1.

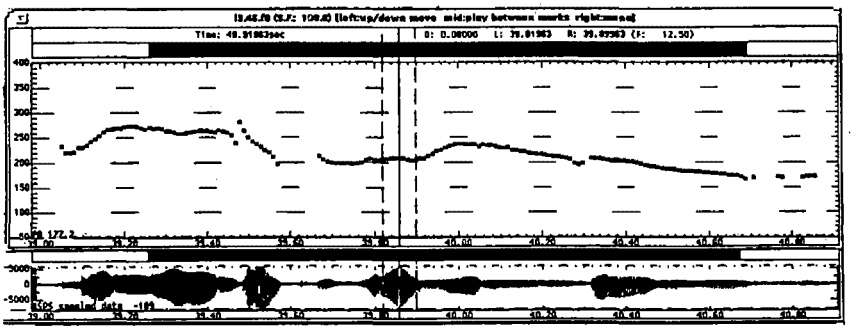


Figure 1. The dashed lines indicate where the target vowel is in the pitch trace. The solid line indicates where fundamental frequency was measured in the target syllable [gwà]. The sentence shown here is [mì nìéndá kùgwà hényùmbá yò dù], "Me, I would like to fall only today."

The corpus was designed to allow examination of the fundamental frequency of high-toned syllables, downstepped high-toned syllables, and low-toned syllables in final and in non-final positions. In order to rule out segmental effects, similar syllables, all involving the sequence [wa], were used to test all of these categories. The word [kùnwá], "to drink," provided the high tone with the syllable [nwá], the word [ná!nwá], "I drank," provided the downstepped high tone with the syllable [!nwá], and the word [kùgwà], "to fall," provided the low tone with the syllable [gwà]. Since the downstep is grammatically conditioned by the subject prefix [ná] in [ná!nwá], "I drank," it was impossible to have identical syllables immediately preceding the target syllable. However, the corpus was designed to minimize such variation.

In order to verify that all three tonal categories of Kipare, namely H, !H, and L, do lower, each word was placed in various positions within carrier sentences: preceded by 0, 2, 3, 4, 5, and 6 syllables; followed by 0, 2, 3, 4, and 5 syllables; and every combination of these. (It was impossible to find appropriate single syllable carrier words in either preceding or following environments.) The preceding and following tone patterns were not uniformly high or uniformly low (again, due to problems finding utterances in the language with all H or all L tones).

Instead, the tone patterns built on the tone pattern of the next shortest sentence. So two syllables preceding the verb had the tone pattern HL, three syllables preceding the verb had the tone pattern LHL, four syllables had the tone pattern LLHL, five syllables had the tone pattern HLLHL, and six syllables had the tone pattern HLLLHL. Similarly for following tone patterns, where two syllables following the verb had the tone pattern HL, three syllables had the tone pattern HLH, four syllables had the tone pattern HLHL, and five syllables had the tone pattern HLHLL. See Appendix 1 for a complete list of sentences.

3. Do all tonal categories lower utterance-finally?

When comparing the mean fundamental frequency of all recorded tokens which were utterance-final with the mean of all recorded tokens which were non-final, it is clear that the fundamental frequency for all three tonal categories is lower utterance finally than utterance medially. Unpaired t-tests show that the means of the utterance final tokens are different from the means of the utterance medial tokens at $p<.0001$ for all three categories. For high-toned targets, $t=-17.8$, for downstepped targets, $t=-11.3$, and for low-toned targets, $t=-18.3$.

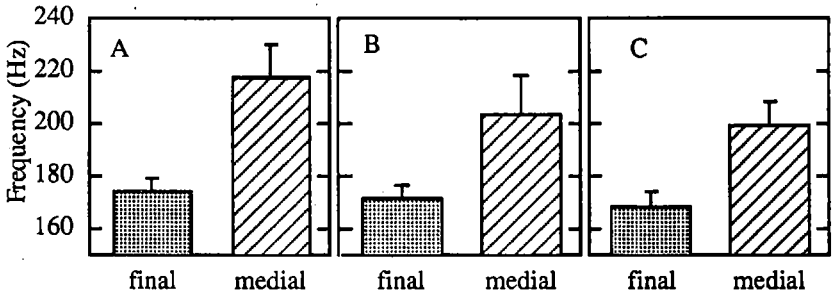


Figure 2. Plot of mean fundamental frequency values with standard deviation bars for utterance final and utterance medial tokens.
A: The F0 of target syllables for all tokens with H targets.
B: The F0 of target syllables for all tokens with !H targets.
C: The F0 of target syllables for all tokens with L targets.

		no. of tokens	mean F0	stand. dev.
H toned target	final	30	174.23 Hz	5.05
	medial	120	217.19 Hz	12.97
!H toned target	final	30	171.52 Hz	4.83
	medial	120	203.45 Hz	15.30
L toned target	final	30	168.07 Hz	6.40
	medial	120	199.49 Hz	8.80

Table 2. Number of tokens, mean F0, and standard deviations for all three tonal categories in final and medial positions.

As Figure 2 A-C show, not only does the phenomenon of final-lowering occur in this Kipare speaker's speech, but also all three tonal categories show final lowering. This could be explained by either the register model or the boundary tone model. However, the distribution of "super-low" tones in the register model must

be stipulated (via a rule inserting register l in a specific position) since !L tones only occur utterance finally. In the boundary tone model, the distribution of "super-low" tones is understood as the effect of boundary tones only occurring at the edges of prosodic categories.

4. Do categories coincide?

Given the register model, the expectation is that high tones occurring utterance-finally would have the same values as downstepped high tones occurring medially since they have identical representations. In order to test this, the same data set was used as was used in section 3, only making different comparisons. Underlying H tones occurring utterance finally were compared with !H tones (derived via having a H toned grammatical marker before a H toned syllable) occurring medially. The prediction is that /H#/ and /!H.../ should have comparable fundamental frequencies when preceded by identical tonal contexts, since both are represented with a H on the primary tier and a l on the register tier. Similarly, !H tones occurring utterance finally were compared with L tones occurring utterance medially. The prediction is that /!H#/ and /L.../ should also have comparable fundamental frequencies when preceded by identical tonal contexts, since both are represented with a L on the primary tier and a l on the register tier.

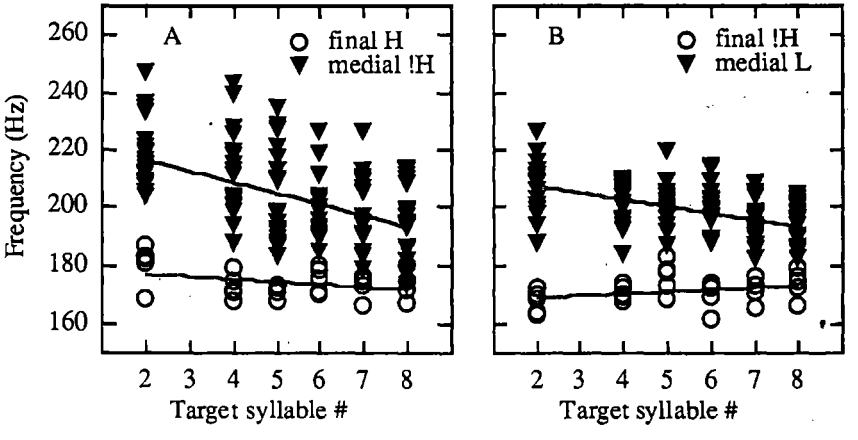


Figure 3.
A: Final high tones compared with medial downstepped high tones
B: Final downstepped high tones compared with medial low tones

It is not the case that final H tones coincide with medial !H tones, as shown in Figure 3A. In Figure 3A, the values of high tones utterance-finally are shown together with the values of downstepped high tones utterance medially. The X-axis shows which syllable number in the utterance the target syllable is. For example, in the utterance [kùnwá], the target syllable [nwá] is syllable number 2 and is in final position. If high tones changed to downstepped high tones utterance-finally, the two groups would be expected to overlap. However, they do not. Similarly, the expectation is that downstepped high tones occurring finally would have the same values as low tones occurring medially, since they have identical representations. Again, this is not the case, as shown in Figure 3B.

In the register model where medial downstepped tones and final high tones have identical representations, another tone change might be cited as the cause of this lack of overlap. For example, many African tone languages have a rule raising the last non-low tone before a low tone. Yoruba (Laniran, 1992) is one such language. Hausa (Inkelas, Leben, and Cobler, 1986) is another. Kipare has an independently attested pre-L raising of this sort. (Odden, personal communication.) However, such a pre-L raising cannot be the explanation for the lack of overlap in these data since none of the target medial !H tones in the corpus preceded a L tone.

Or, instead of another tone change to account for this lack of overlap, perhaps "phonetic implementation" could be cited. That is, the fundamental frequency targets are identical at some level but then phonetic effects "bump down" the final tones. This expresses the same idea as is found in Pierrehumbert (1980), where she argues that the hierarchical representation would not be an alternative to replace tone mapping rules, but must be supplemented by rules expressing the same regularities. The question is, if this sort of "phonetic implementation" is a necessary supplement to the register model, then why introduce the additional level of structure involved in the register tier at all? Why not read the phonetic values directly from the string of tones? As Pierrehumbert (1980) argues, having a level of representation between the underlying sequence of tones and the fundamental frequency contour is superfluous, since it is possible to map tones directly into fundamental frequency values. Thus, the idea of quantitative rules of phonetic implementation supplementing qualitative, category changing rules of final lowering seems to involve an unnecessarily complex system.

In the boundary tone model, the final tones would be expected to be a constant proportion of the medial tones. One problem with this comparison is that it is unclear exactly what is meant by "medial" here. Should F0 values for tones in final position be compared to F0 values of immediately preceding tones or to F0 values a certain amount of time earlier in the utterance? The answer depends on whether final lowering affects a certain number of syllables or a certain window of time. Without making a claim either way, but in order to get a general idea of the proportions between final and medial values, the values for mean F0s were taken from Table 2, which averages over all medial positions. The results are that values for H tones in final position are .80 of values for H tones in medial position, values for !H tones in final position are .84 of values for !H tones in medial position, and values for L tones in final position are also .84 of L tones in medial position. These results are suggestive of the boundary tone model, where final tones lower by a certain amount.

5. Thinking locally or acting globally?

As shown above, the fundamental frequency lowers dramatically utterance-finally. However, the question is whether this lowering is just a local effect, affecting only a single tone-bearing unit, or whether the phenomenon affects previous tone-bearing units as well. In order to test this, the same data set as in section 3 was examined. This time, target syllables at varying distances from the end of the utterance were compared. Distance from the end of the utterance was measured in terms of number of syllables.

The closer the target syllable is to the end of the utterance, the lower the fundamental frequency is. Figures 4 A-C show mean values of the fundamental frequency (in Hz) plotted against the number of syllables following the target syllable in the utterance. In general, the fundamental frequency drops lower and lower when followed by less and less syllables, plunging at extreme utterance-final position. Targets followed by a single syllable were not available for comparison (due to problems finding appropriate words in the language). However, in all three

graphs the drop in frequency between 2 and 0 is clearly greater than twice the drop in frequency between any other two points along the X-axis. This leads to the speculation that if utterances where the target syllable was followed by a single syllable were available, the mean frequency would be slightly higher than halfway between the mean for 0 and the mean for 2.

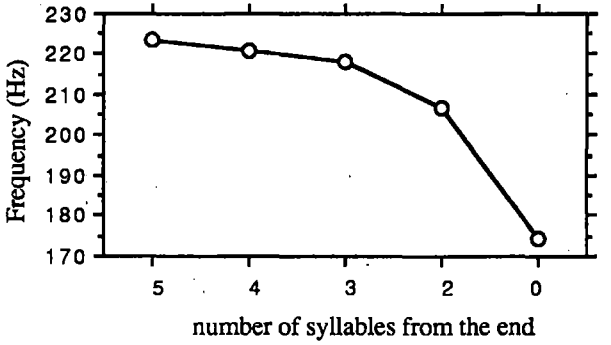


Figure 4A. Mean values of F0 for H target syllables

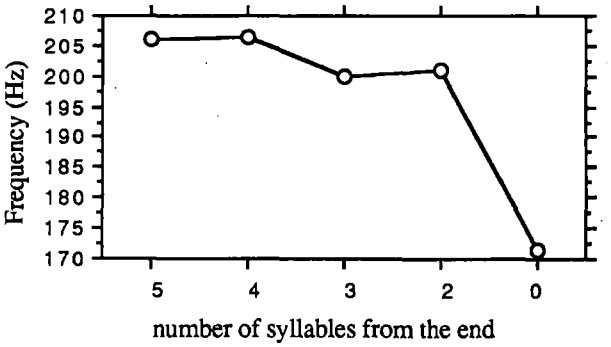


Figure 4B. Mean values of F0 for !H target syllables

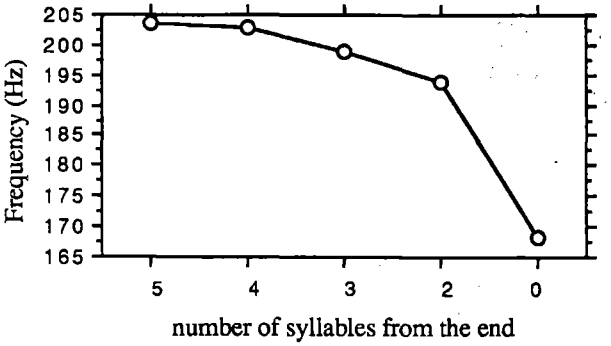


Figure 4C. Mean values of F0 for L target syllables

A 2-factor Analysis of Variance (ANOVA) was performed using the number of syllables preceding the target, the number of syllables following the target, and the fundamental frequency as factors. The ANOVA shows that the number of following syllables is statistically significant at p=.0001 for H, !H, and L in determining the fundamental frequency of the target syllable.

The question is whether this statistical significance is just a result of the large difference between extreme final position and all other positions or whether this also reflects differences among various non-final positions. The results of a post-hoc Tukey-Kramer test are given in Table 3. Table 3 lists all of the pairs of syllable positions from the end that were indeed significantly different from each other at a .05 level.

H targets		!H targets		L targets	
0	2	0	2	0	2
0	3	0	3	0	3
0	4	0	4	0	4
0	5	0	5	0	5
2	3	--	--	--	--
2	4	--	--	2	4
2	5	--	--	2	5

Table 3. Pairs of syllable positions from the end that were significantly different from each other.

According to Table 3, a target syllable followed by 2 syllables does show final lowering effects for H targets and for L targets (but inexplicably, not for !H targets). These data do not indicate whether final lowering affects a certain number of syllables from the end or a certain window of time from the end, since the measurements used in this study involve number of syllables, not time. But these results do show that final lowering affects syllables before the final TBU.

Another question about the significance of the number of following syllables is whether the gradual falling-off shapes in Figure 4 A-C must be attributed to final lowering or whether they can be attributed either to a general declination trend or to the number of preceding register shifts (since the number of downsteps preceding the target syllable was not controlled for in the corpus by having all L or all H preceding environments, as discussed in section 2). The number of preceding syllables is in fact significant at p=.0001 for H, !H, and L tones, indicative of declination. However, the statistical significance of position from the beginning does not affect the validity of the statistical significance of position from the end since the Analysis of Variance tests each factor independently. For example, the value of a target syllable 0 syllables from the end is calculated across all the different preceding environments. In the corpus, the same set of preceding environments were used for each position from the end, as shown in the example in (3).

(3)

A. Final Position	B. Followed by 2 syllables
[kùnwá]	[kùnwá íkì]
[ézà kùnwá]	[ézà kùnwá íkì]
[nìéndà kùnwá]	[nìéndà kùnwá íkì]
[mì nìéndà kùnwá]	[mì nìéndà kùnwá íkì]
[íkì nìéndà kùnwá]	[íkì nìéndà kùnwá íkì]
[íkì mì nìéndà kùnwá]	[íkì mì nìéndà kùnwá íkì]

Although there may be register shifts in the preceding environment, there will be the same number of register shifts being calculated in at each position from the end.

In sum, the shape of the figures in Figure 4 A-C is indicative of final lowering as separate from declination or register shifts.

In the register model, only the extreme final syllable would be affected by final lowering, but in the boundary tone model, the effect is expected to "reach in" from the end of the sentence. The results obtained here show that final lowering affects more than just the last syllable, which does not match the predictions of the register model.

One further problem related to this phenomenon is that in a sequence of downstepped H tones, all of the tones lower to L utterance finally whereas when there is a HH sequence, only the last H lowers to !H utterance finally (Odden, 1986a and b). This suggests that these are two different processes (and so would pose a problem to any model attempting to provide a unified account). However, the data examined here involve only monosyllabic verbs, so there is no evidence bearing on this problem in this study.

6. Is there a contrast?

Final-lowered utterances are not the only possible utterance type in Kipare. There is also a contrasting utterance type with final raising of pitch that expresses doubt, disbelief or incredulity. Sentences segmentally identical to the declaratives used earlier and with the same lexical tone patterns were elicited, but in contexts intended to express disbelief. (Only sentences with third-person subjects were used in this section, since first-person subjects seemed pragmatically odd in such contexts.) Figure 5 shows a comparison of an incredulous sentence (upper panel) with a declarative sentence (lower panel). See Appendix 2 for a complete list of utterances used in this section of the study.

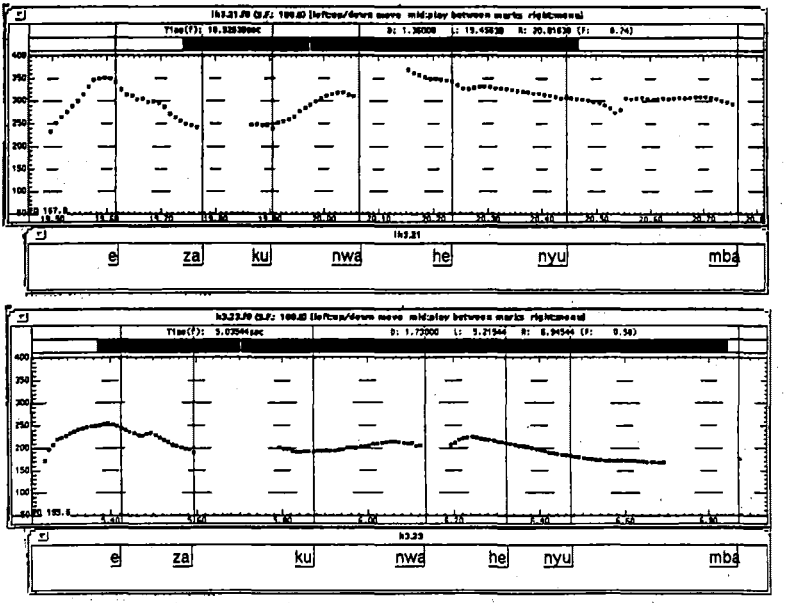


Figure 5. Upper panel: incredulous. Lower panel: declarative.
[ézà kùnwá hényùmbá] "He/she comes to drink in the house."

The expression of incredulity via manipulation of pitch is not unique to Kipare. Hirschberg and Ward (1992) show that for the L*+H L H% (using Pierrehumbert's notation, elsewhere referred to as rise-fall-rise) contour in English, the primary factor distinguishing an incredulity interpretation from an uncertainty interpretation is pitch range. Jun and Oh (1994) show that in Korean, although not all speakers use the same strategy for expressing incredulity, larger pitch range is one of the factors manipulated to distinguish between incredulity questions and wh-questions. Miura and Hara (in press) show that in Osaka Japanese, sentence-initial F0 lowering and sentence-final F0 raising are some of the characteristics of rhetorical questions, which express disbelief or incredulity.

Not only does the shape of the pitch trace differ in sentences expressing incredulity from declaratives, but also the pitch range is greatly expanded.

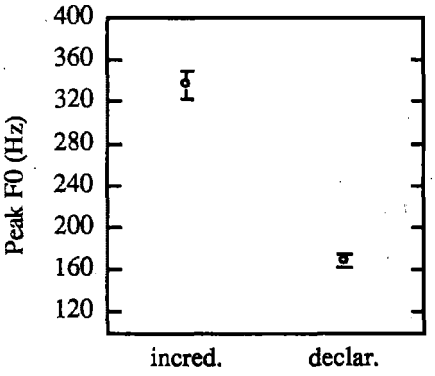


Figure 6. The mean and standard deviations for the peak F0 values of 10 tokens of each utterance type, measured at the highest point in each sentence.

The overall pitch-range expansion evident in incredulous sentences in Kipare corresponds to the "global raising" described in Inkelas and Leben. They dismiss this as "phonetic implementation." This again raises the question of the necessity of an intermediate level of representation if a phonetic interpretation can be given directly to the string of tones. And although the expansion of pitch range does provide a contrast between utterance types in Kipare, the effect may be more continuous than categorical in nature. That is, there may be gradient degrees of pitch range expansion expressing gradient degrees of incredulity. This would accord with Inkelas and Leben's depiction of pitch range expansion as more "phonetic" in nature. Even phenomena relegated to phonetic implementation should be explicable in the theory, though. Pierrehumbert (1980) assumes that "pitch range does not exist in the model except as it is represented in the value of particular tones" (p. 105). Ayers (1994), in constructing hierarchical pitch trees to capture relationships between phrases with increased and decreased pitch range, assumes no a priori categories of pitch range such as high, mid, and low. Even Ladd (1994), while arguing against free gradient variability and for constant relative F0, nevertheless assumes that "the overall modifications of pitch range are gradient." Again, further empirical data would be needed to settle the question of the representation of pitch range in Kipare.

A third utterance type, with the same shape as the final-lowered declarative sentences but with the expanded pitch range seen in the incredulous sentences,

expresses yes/no questions. Such sentences would actually elicit a "yes" or "no" response from the hearer. All three types are shown in Figures 7 and 8.

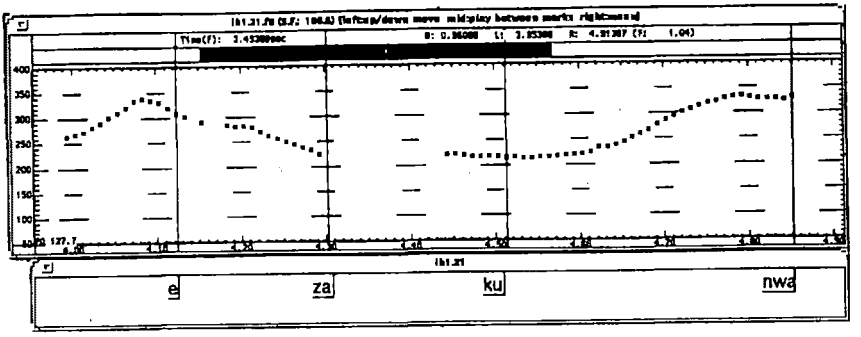


Figure 7A. [ézà kùnwá] (incredulous)
"He/ she comes to drink?!"

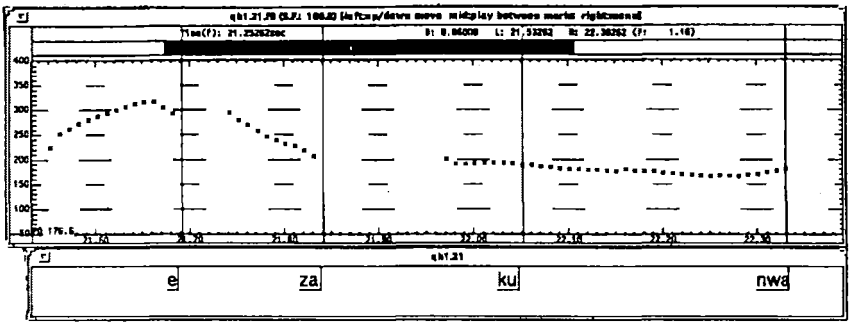


Figure 7B. [ézà kùnwá] (yes/no question)
"Does he/she come to drink?"

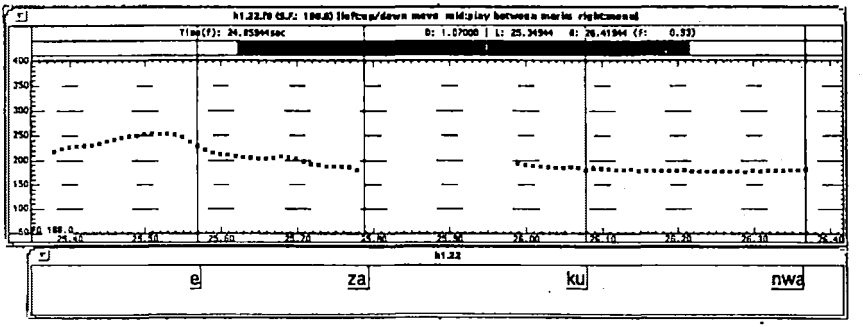


Figure 7C. [ézà kùnwá] (declarative)
"He/she comes to drink."

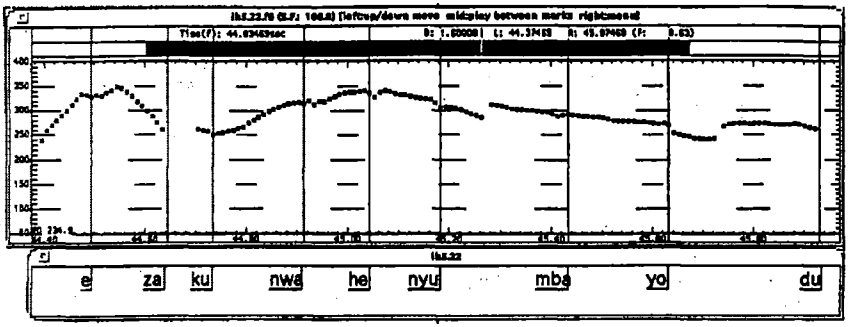


Figure 8A. [ézà kùnwá hényùmbá yò dù] (incredulous)
"He/she comes to drink in the house only today?!"

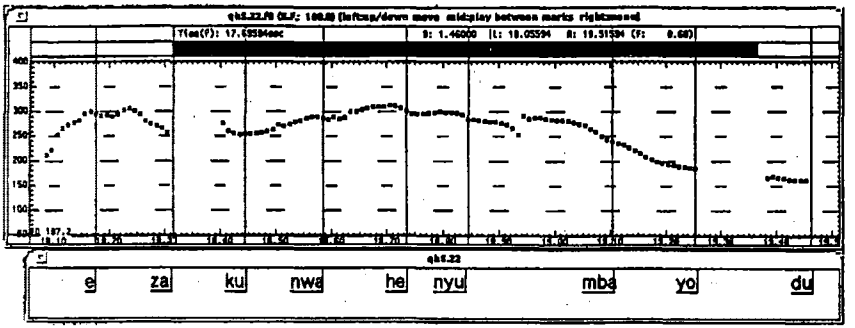


Figure 8B. [ézà kùnwá hényùmbá yò dù] (yes/no question)
"Does he/she come to drink in the house only today?"

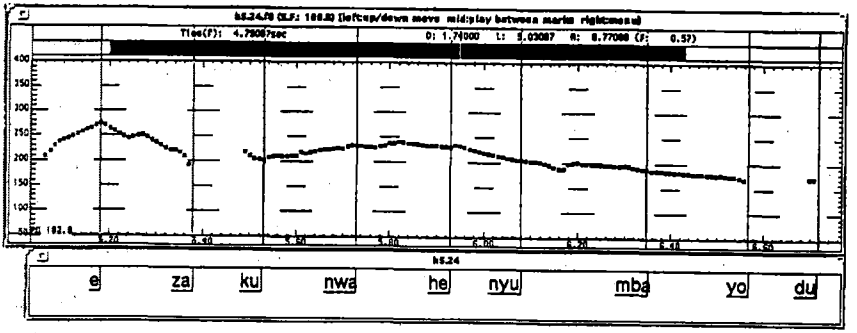


Figure 8C. [ézà kùnwá hényùmbá yò dù] (declarative)
"He/she comes to drink in the house only today."

Again, using these three types of tunes is not unique to Kipare. Shen (1990) describes three tunes of Mandarin Chinese:

"Tune I: starting with a mid key, moving upward to a mid-high key at the highest peak, falling to a low register at the ending point.
Tune II: starting with a mid-high key, moving upward to a high key at the highest peak, dropping, but not too low, ending in the high or mid-high register.
Tune III: starting with a mid-high key, moving upward to a high key at the highest peak, stepping down and ending with a low key." (page 26)

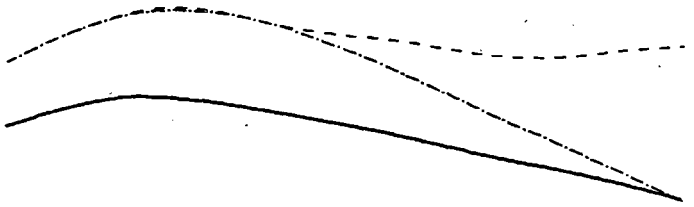


Figure 9. Shen's figure 2.5, showing the three tunes of Mandarin Chinese (used with permission of the author)

These three tunes in Mandarin involve the same combinations of elements as the three tunes in Kipare: non-expanded pitch range with final lowering, expanded pitch range with final lowering, or expanded pitch range with final raising. In Mandarin too, according to Shen, the three tunes mark different utterance types. "Tune I for assertive, Tune II for question ending in a high register, and Tune III for interrogative ending in a low register" (page 27).

Furthermore, Shen cites Hermann's (1942) observation that high pitch is used for interrogatives in many languages, with the understanding that high pitch can be "not only a rising terminal but can also mean a relatively high overall pitch level" (page 12). The evidence from Kipare, where expanded pitch range signals yes/no questions, provides further confirmation of this observation.

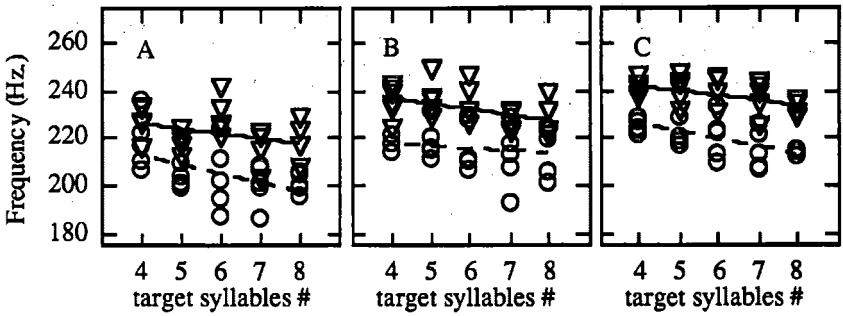
So the use of various tunes to signal different utterance types is a common phenomenon cross-linguistically, in both lexical tone languages and in other languages.

Regarding the issue of final lowering, the contrast in Kipare between declarative sentences and yes/no questions on the one hand and sentences expressing incredulity on the other (manifested with rising vs. falling pitch utterance finally) is a contrast between utterance types rather than a lexical contrast. So it does not seem appropriate to analyze the contrast as an effect of a contrast in lexical tones. Instead of a tone or tones associated with an individual tone-bearing-unit, as implied by the register model, final lowering and raising may be viewed as the effect of a tone associated with the entire utterance and thus having scope over the whole sentence, as implied by the boundary tone model.

7. What is the domain of final lowering?

In section 3 through section 6, each sentence was produced in isolation. So the "final" lowering observed was assumed to be sentence-final lowering. However, Silverman (1987) suggests that final lowering is a property of the end of

a prosodic paragraph rather than the end of a phrase. In order to explore the domain of final lowering in Kipare, the sentence containing the target syllable was followed by another sentence. See appendix 3 for the list of sentences used in this part of the study.



O target syllable in a discourse-final carrier sentence (dashed regression line)

▽ target syllable in a carrier sentence followed by 1 sentence (solid regression line)

Figure 10.
A: The target syllable is utterance-final.
B: The target syllable is followed by 3 syllables.
C: The target syllable is followed by 4 syllables.

There were 25 tokens spoken in a sentence in isolation and 25 tokens spoken in a sentence followed by another sentence for each of A, B, and C in (18).

As shown in figure 10, the fundamental frequency values of the target syllables were lower in discourse final position than in sentence final (but not discourse final) position. This is indicated by the difference between the two regression lines in each graph, where the lower one is for sentences spoken in isolation and the lower one is for sentences followed by another sentence. Hirschberg and Pierrehumbert (1986) suggest that a decrease in final-lowering effects can indicate the absence of a boundary between discourse segments. Grosz and Hirschberg (1992) also note the importance of pitch range in signaling topic structure. Since the carrier sentence in this corpus was designed to be conceptually continuous with the sentence containing the target syllable, it could be that the decrease in final lowering effects can be attributed to marking the semantic or conceptual connection between the two sentences.

Thus Silverman's suggestions about the domain of final lowering are borne out in Kipare. The domain of final lowering seems to be bigger than just the sentence, although further study would be needed to determine exactly what the extent of the domain is. No matter what the exact domain for final lowering, the fact remains that either the register model or the boundary tone model must be enriched so as to be able to refer to more than just the sentence level in describing final lowering.

8. Conclusion

This study compares the register model with the boundary tone model in analyzing final lowering in Kipare. Several factors have been examined. All tonal

categories lower, but do not coincide with the next category down. This does not accord with the prediction of the register model. The final tones do seem to be a constant proportion of preceding tones, which does match the prediction of the boundary tone model. The effects of final lowering are non-local, affecting more than just the extreme final tone-bearing unit. This does not match the predictions of the register model, but it does match the predictions of the boundary tone model. Contrasts exist at the utterance level. This would be best handled by the boundary tone model, since the boundary tone has scope over the entire utterance. The domain of final lowering is greater than the sentence, which cannot be handled by either model. Overall, these factors are suggestive of the effects of a boundary tone having scope over the entire utterance rather than the effects of a register tone associated with a single tone-bearing unit.

9. Works Cited

Ayers, Gayle M. (1994). Discourse Function of Pitch Range in Spontaneous and Read Speech. Ohio State University Working Papers in Linguistics. 44: 1-49.

Beckman, Mary and Janet Pierrehumbert. (1992). Comments on Chapters 14 and 15. Papers in Laboratory Phonology II: Gesture, Segment, Prosody. G.J. Docherty and D.R. Ladd, eds. Cambridge University Press: Cambridge. 387-397.

Clements, George N. (1981). The Hierarchical Representation of Tone Features. Harvard Studies in Phonology, vol. II.

Clements, G.N. and K.C. Ford. (1981). On the Phonological Status of Downstep in Kikuyu. Phonology in the 1980s. D. L. Goyvaerts, ed. 309-358.

Elugbe, Ben Ohi. (1977). Some Implications of Low Tone Raising in Southwestern Edo. Studies in African Linguistics, supp.7. 53-62.

Entropic Research Laboratory, Inc. (1993). *Waves+ 5.0*. AT&T Bell Laboratories. Washington, D.C.

Grosz, Barbara and Julia Hirschberg. (1992). Some Intonational Characteristics of Discourse Structure. ICSLP 92 Proceedings. University of Alberta. 429-432.

Gussenhoven, C. and A.C.M. Rietveld. (1988). Fundamental frequency declination in Dutch: testing three hypotheses. Journal of Phonetics. 16: 355-369.

Hermann, Eduard. (1942). Problem der Frage. Nachrichten v.d. Akademie der Wissenschaft in Göttingen, Philologische Historische Kasse, 121-408. (Cited in Shen, 1990).

Hirschberg, Julia and Janet Pierrehumbert. (1986). The Intonational Structuring of Discourse. Proceedings of the 24th Annual Meeting of the Association for Computational Linguistics. Columbia University, New York. 136-144.

Hirschberg, Julia and Gregory Ward (1992). The influence of pitch range, duration, amplitude and spectral features on the interpretation of the rise-fall-rise intonation contour in English. Journal of Phonetics. 20:241-251.

Inkelas, Sharon and William R. Leben. (1990) Where phonology and phonetics interact: the case of Hausa intonation. Papers in Laboratory Phonology I: Between the Grammar and Physics of Speech. J. Kingston and M. Beckman, eds. Cambridge University Press: Cambridge. 17-34.

Inkelas, Sharon, William R. Leben, and Mark Cobler. (1986). The Phonology of Intonation in Hausa. Proceedings of NELS 17.

Jun, Sun-Ah and Mira Oh. (1994). A Prosodic Analysis of Three Sentence Types With "Wh" Words in Korean. Proceedings of the 1994 International

Conference on Spoken Language Processing. The Acoustical Society of Japan. 323-326.
Ladd, D. Robert. (1994). Constraints on the gradient variability of pitch range, or, Pitch Level 4 Lives! Papers in Laboratory Phonology III: Phonological Structure and Phonetic Form. P. Keating, ed. Cambridge University Press: Cambridge. 43-63.
Ladefoged, Peter. (1982). A Couse in Phonetics, second edition. Harcourt Brace Jovanovich, Inc.
Laniran, Yetunde Olabisi. (1992). Intonation in Tone Languages: the Phonetic Implementation of Tones in Yoruba. PhD Dissertation. Cornell University.
Liberman, Mark and Janet Pierrehumbert. (1984). Intonational Invariance Under Changes in Pitch Range and Length. Language Sound Structure. M. Aronoff and R. Oehrle, eds. MIT Press: Cambridge, MA.
Miura, Ichiro and Noriyo Hara. (in press). Production and Perception of Rhetoricl Questions in Osaka Japanese. To appear in Journal of Phonetics.
Odden, David. (1986a) On the Role of the Obligatory Contour Principle in Phonological Theory. Language, 62:2. 353-383.
Odden, David. (1986b) Three dialects of Kipare. Current Approaches to African Linguistics, 3. 257-280.
Pierrehumbert, Janet B. (1980). The Phonology and Phonetics of English Intonation. PhD Dissertation. MIT.
Pierrehumbert, Janet B. and Mary E. Beckman. (1988) Japanese Tone Structure. Linguistic Inquiry Monograph 15. MIT Press.
Roberts, R. Ruth. (1992). A Non-Metrical Theory of Sukuma Tone. Ohio State University Working Papers in Linguistics. 41:135-148.
Shen, Susan. (1990). The Prosody of Mandarin Chinese. University of California Press.
Silverman, Kim. (1987). The Structure and Processing of Fundamental Frequency Contours. PhD Dissertation. University of Cambridge.
Snider, Keith and Harry van der Hulst. (1993) Issues in the Representation of Tonal Register. in The Phonology of Tone; the Representation of Tonal Register. Harry van der Hulst and Keith Snider, eds. Mouton de Gruyter: Berlin. 1-27.
Thorsen, Nina. (1985). Intonation and text in Standard Danish. Journal of the Acoustical Society of America. 77: 1205-1216.

Appendix 1: Corpus of Utterances used for section 3, section 4, and section 5

[kùnwá]	"to drink"
[ézà kùnwá]	"he/she comes to drink"
[nìéndà kùnwá]	"I would like to drink"
[mì nìéndà kùnwá]	"(I) I would like to drink"
[íkì nìéndà kùnwá]	"now I want to drink"
[íkì mì nìéndà kùnwá]	"now (I) I want to drink"
[ná!nwá]	"I drank"
[áhà ná!nwá]	"but I drank"
[mì áhà ná!nwá]	"but me, I drank"
[yò mì áhà ná!nwá]	"today I have drunk"
[íkì mì áhà ná!nwá]	"but I have drunk"
[íkì yò mì áhà ná!nwá]	"but today I have drunk"
[kùgwà]	"to fall"

[íkì kùgwà]	"to fall now"
[nìéndà kùgwà]	"I would like to fall"
[mì nìéndá kùgwà]	"(I) I would like to fall"
[íkì mì nìéndà kùgwà]	"now (I) I want to fall"
[kùnwá íkì]	"to drink now"
[ézà kùnwá íkì]	"he/she comes to drink now"
[nìéndà kùnwá íkì]	"I would like to drink now"
[mì nìéndà kùnwá íkì]	"(I) I would like to drink now"
[íkì nìéndà kùnwá íkì]	"now I want to drink now"
[íkì mì nìéndà kùnwá íkì]	"now (I) I want to drink now"
[ná!nwá íkì]	"I drank now"
[áhà ná!nwá íkì]	"but I drank now"
[mì áhà ná!nwá íkì]	"but me, I drank now"
[yò mì áhà ná!nwá íkì]	"today I have drunk now"
[íkì mì áhà ná!nwá íkì]	"but I have drunk now"
[íkì yò mì áhà ná!nwá íkì]	"but today I have drunk now"
[kùgwà íkì]	"to fall now"
[íkì kùgwà íkì]	"(now) to fall now"
[nìéndà kùgwà íkì]	"I would like to fall now"
[mì nìéndá kùgwà íkì]	"(I) I would like to fall now"
[íkì mì nìéndà kùgwà íkì]	"now (I) I want to fall now"
[kùnwá hényùmbá]]	"to drink in the house"
[ézà kùnwá hényùmbá]	"he/she comes to drink in the house"
[nìéndà kùnwá hényùmbá]	"I would like to drink in the house"
[mì nìéndà kùnwá hényùmbá]	"(I) I would like to drink in the house"
[íkì nìéndà kùnwá hényùmbá]	"now I want to drink in the house"
[íkì mì nìéndà kùnwá hényùmbá]	"now (I) I want to drink in the house"
[ná!nwá hényùmbá]	"I drank in the house"
[áhà ná!nwá hényùmbá]	"but I drank in the house"
[mì áhà ná!nwá hényùmbá]	"but me, I drank in the house"
[yò mì áhà ná!nwá hényùmbá]	"today I have drunk in the house"
[íkì mì áhà ná!nwá hényùmbá]	"but I have drunk in the house"
[íkì yò mì áhà ná!nwá hényùmbá]	"but today I have drunk in the house"
[kùgwà hényùmbá]	"to fall in the house"
[íkì kùgwà hényùmbá]	"to fall in the house now"
[nìéndà kùgwà hényùmbá]	"I would like to fall in the house"
[mì nìéndá kùgwà hényùmbá]	"(I) I would like to fall in the house"
[íkì mì nìéndà kùgwà hényùmbá]	"now (I) I want to fall in the house"
[kùnwá hényùmbá yò]	"to drink in the house today"
[ézà kùnwá hényùmbá yò]	"he/she comes to drink in the housetoday"
[nìéndà kùnwá hényùmbá yò]	"I would like to drink in the house today"
[mì nìéndà kùnwá hényùmbá yò]	"(I) I would like to drink in the house today"
[íkì nìéndà kùnwá hényùmbá yò]	"now I want to drink in the house today"
[íkì mì nìéndà kùnwá hényùmbá yò]	"now (I) I want to drink in the house today"
[ná!nwá hényùmbá yò]	"I drank in the house today"
[áhà ná!nwá hényùmbá yò]	"but I drank in the house today"

[mì áhà ná!nwá hényùmbá yò] "but me, I drank in the house today"
[yò mì áhà ná!nwá hényùmbá yò] "today I have drunk in the house today"
[íkì mì áhà ná!nwá hényùmbá yò] "but I have drunk in the house today"
[íkì yò mì áhà ná!nwá hényùmbá yò] "but today I have drunk in the house today"

[kùgwà hényùmbá yò] "to fall in the house today"
[íkì kùgwà hényùmbá yò] "(now) to fall in the house today"
[nìéndà kùgwà hényùmbá yò] "I would like to fall in the house today"
[mì nìéndá kùgwà hényùmbá yò] "(I) I would like to fall in the house today"
[íkì mì nìéndà kùgwà hényùmbá yò] "now (I) I want to fall in the house today"

[kùnwá hényùmbá yò dù] "to drink only today"
[ézà kùnwá hényùmbá yò dù] "he/she comes to drink only today"
[nìéndà kùnwá hényùmbá yò dù] "I would like to drink only today"
[mì nìéndà kùnwá hényùmbá yò dù] "(I) I would like to drink only today"
[íkì nìéndà kùnwá hényùmbá yò dù] "now I want to drink only today"
[íkì mì nìéndà kùnwá hényùmbá yò dù] "now (I) I want to drink only today"

[ná!nwá hényùmbá yò dù] "I drank only today"
[áhà ná!nwá hényùmbá yò dù] "but I drank only today"
[mì áhà ná!nwá hényùmbá yò dù] "but me, I drank only today"
[yò mì áhà ná!nwá hényùmbá yò dù] "today I have drunk only today"
[íkì mì áhà ná!nwá hényùmbá yò dù] "but I have drunk only today"
[íkì yò mì áhà ná!nwá hényùmbá yò dù] "but today I have drunk only today"

[kùgwà hényùmbá yò dù] "to fall only today"
[íkì kùgwà hényùmbá yò dù] "(now) to fall only today"
[nìéndà kùgwà hényùmbá yò dù] "I would like to fall only today"
[mì nìéndá kùgwà hényùmbá yò dù] "(I) I would like to fall only today"
[íkì mì nìéndà kùgwà hényùmbá yò dù] "now (I) I want to fall only today"

Appendix 2: Corpus of utterances used for section 6

[ézà kùnwá] "he/she comes to drink"
[ézà kùnwá íkì] "he/she comes to drink now"
[ézà kùnwá hényùmbá] "he/she comes to drink in the house"
[ézà kùnwá hényùmbá yò] "he/she comes to drink in the house today"
[ézà kùnwá hényùmbá yò dù] "he/she comes to drink " " " only today"

Appendix 3: Corpus of utterances used for section 7

The sentence following the carrier sentence containing the target syllable was:
[úkò nzé hénà kìrúkè] "it is hot outside."

The target sentences used were:
[ézà kùnwá] "he/she comes to drink"
[nìéndà kùnwá] "I would like to drink"
[mì nìéndà kùnwá] "(I) I would like to drink"
[íkì nìéndà kùnwá] "now I want to drink"
[íkì mì nìéndà kùnwá] "now (I) I want to drink"

[ézà kùnwá hényùmbá] "he/she comes to drink in the house"
[nìéndà kùnwá hényùmbá] "I would like to drink in the house"

[mì nìéndà kùnwá hényùmbá]	"(I) I would like to drink in the house"
[íkì nìéndà kùnwá hényùmbá]	"now I want to drink in the house"
[íkì mì nìéndà kùnwá hényùmbá]	"now (I) I want to drink in the house"
[ézà kùnwá hényùmbá yò]	"he/she comes to drink in the house today"
[nìéndà kùnwá hényùmbá yò]	"I would like to drink in the house today"
[mì nìéndà kùnwá hényùmbá yò]	"(I) I would like to drink in the house today"
[íkì nìéndà kùnwá hényùmbá yò]	"now I want to drink in the house today"
[íkì mì nìéndà kùnwá hényùmbá yò]	"now (I) I want to drink in the house today"