*Nupe tonology and the categorical identity of verb copy tones: a pilot experimental study**

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Abstract

In both the descriptive literature and intuitions of native speakers, verbs participating in Nupe verbal copy constructions are reported to bear tones of the same category, such that the tonal category of the copy is a function of the category of the base. This paper presents experimental findings that confirm these claims, despite rather significant phonetic differences in their tonal realizations. We show that these differences are attributable to independent PF phenomena such as pitch declination and IP-final tone shift. The study also addresses other aspects of Nupe tonology experimentally and briefly considers the syntactic/architectural ramifications of the findings.

1 Introduction

This paper reports on the findings of a pilot experimental study on Nupe[1] tone. While the tone system of the language has been adequately described for some time now (Banfield and Macintyre (1915), Smith (1967), Madugu (1980)) and its interaction with the phonology has been accounted for with some success (George (1970), Hyman (1970), (1973), Harms (1973)), experimental studies have yet to

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[1] Nupe is a Kwa language of the Benue-Congo sub-family of the Niger-Congo language family of Africa. The Nupe spelling employed in this paper conforms to the modern orthography as described in Madugu 1980, and thus differs slightly from the classic orthographies of Banfield 1914, 1915 and Banfield and Macintyre 1915. Abbreviations used in the glosses of example sentences include the following: FUT, future; LOC, locative; PERF, perfect; PRES, present; PRT, particle, SG, singular. In the example sentences of this paper, high tone is marked with an acute accent over the vowel and low tone by a grave accent. Mid tones are unmarked and contour tones are notated with the appropriate combination of acute and grave accents. With respect to the Nupe transcriptions in the pitch-track data, high, low, and rising tones are represented as (H), (L), and (R) respectively following the vowels they are realized on. Here as well, mid tones are unmarked.

corroborate these results. The work reported in this paper represents a first step in this direction; the results presented are thus the first of their kind for the language.

The central issue addressed in this study is whether lexical tone is preserved in Nupe verbal copy constructions, as reported in descriptive accounts (Smith (1970)) and reflected in the orthography. The data below illustrate such copy constructions. Syntactically, the verb is doubled and separated from its copy by Case-bearing arguments (objects and locative expressions, but not embedded clauses (CPs)). Semantically, these sentences are typically ambiguous between emphatic (polarity focus) interpretations and Yes/No question readings.[2] Speakers judge both instantiations of the verb to share the same tonal specification.

(1) a. Mángòrò **bá** **bá**.
mango be sour be sour
'The mango was ACTUALLY sour.'
'Was the mango sour?'

b. Musa **gan** **gan** ganan wun bà nakàn.
Musa say say that he eat meat
'Musa ACTUALLY said that he ate meat.'
'Did Musa say that he ate meat?'

c. Musa **tsi** emi o **tsi**.
Musa lie house LOC lie
'Musa ACTUALLY lied down in the house.'
'Did Musa lie down in the house?'

d. Musa **yà** etsu èwò **yà**.
Musa give chief garment give
'Musa DID give the chief a garment.'
'Did Musa give the chief a garment?'

A priori, we might expect the tones on both copies to be identical – this is, after all, a *copy* construction. Nonetheless, there are copy constructions/operations in the language in which tone is not faithfully copied. A case in point is verb reduplication, in which the reduplicant bears a mid tone regardless of the underlying tone on the base. The following data illustrate that the reduplicative morpheme is a prefix that consists of a copy of the first consonant of the base and a high vowel bearing a mid tone that matches the first vowel of the base in roundness, backness, and nasality.

[2] See Kandybowicz 2002 for a detailed account of the syntactic and semantic details of this ambiguity.

(2)	gé	'be good'	gi-gé	'goodness'
	gó	'tie'	gu-gó	'tying'
	go	'grind'	gu-go	'grinding'
	du	'cook'	du-du	'cooking'
	dà	'push'	di-dà	'pushing'
	gò	'receive'	gu-gò	'receiving'

To adequately address this issue, a more fine-grained understanding of Nupe tonology and intonational phonology is required. The results of several acoustic analyses of the speech of a native speaker of Nupe are presented. Included among the findings are: boundary tone phenomena in declarative and verb doubling sentences, rate of pitch declination for two adjacent syllables in each tonal category, effects of tonal coarticulation, and categorical overlapping of tones and tone ranges. Once these factors are taken into consideration, the tonal realizations of the verb and its double can be shown to be phonologically identical, in accord with native speaker intuitions.

The significance of this study extends beyond the domains of tonology and experimental phonology, however. The verb-doubling phenomenon illustrated in (1) raises numerous syntactic questions. In such sentences, how are the two instantiations of the verb related? That is, are they independent lexical items or is the doubled verb derived from its clause-mate somehow? Related to this question is the issue of exactly where in the clausal hierarchy these verbal elements reside and how they come to occupy those positions. If the verb and its double are distinct lexical items functioning independently of each other, it would seem reasonable to analyse them as base-generated in distinct syntactic positions, that is, as quasi serial verb constructions. However, if the verb and its double are related by way of copying/reduplication, a competing analysis becomes possible whereby the original verb is copied into a higher syntactic position and its trace is spelled-out rather than deleted, following Chomsky's (1995) Copy Theory of movement. How can we choose among these competing analyses? Because both approaches rely crucially on the nature of the doubled element and its relation to the other verb, our acoustic analysis can shed light on these syntactic questions. The finding that both the verb and its copy are both specified for the same tone *phonologically* (despite obvious *phonetic* differences) and interpreted as semantically identical provides adequate motivation for a copy theoretic analysis of Nupe verb doubling constructions. Thus, the phenomenon of Nupe verb copying provides a window with which to explore the interfacing of the syntactic, PF (phonetic form), and semantic components of grammar.

2 Background and preliminary observations

We begin with a brief description of the tone system of the language and look at its leading analysis in the literature. We turn next to a few informal observations about the tonology and intonation of Nupe. These observations drive the direction, approach and methodology of the present study.

2.1 The Nupe tone inventory

Five contrastive tones are attested in Nupe: high (H), mid (M), low (L), rise (LH) and fall (HL).

(3)	bé 'to come'		èd`é	'cloth'
	be 'to add to'		d´è	'outside'
	bè 'to resemble'			

George (1970) argues that Nupe is a three-tone language underlyingly: H, M and L tones are lexical; rising and falling tones are derived. He observes that rising tones are in complementary distribution with high tones in so far as rises are limited to appearing only after voiced consonants which are themselves preceded by a low tone. High tones can appear anywhere but in this environment.

(4) ètá 'haste' èd`á 'drought'

Rising tones are argued to result from the spreading of an L tone across a voiced consonant onto a following H. George accounts for the complementarity of rising and high tones seen in (4) by claiming that voiceless consonants block tone spreading in the language[3]. Falling tones, on the other hand, are claimed to derive from the deletion of either a H or M tone (usually due to hiatus resolution (Kawu (2000)) and the subsequent reassociation of the delinked tone to an immediately following L. This analysis predicts that whereas there is only one variety of rising tone (LH), there are two types of falling tones (HL, ML). The existence of these two distinct falling tones has yet to be confirmed experimentally. The present study, however, does not address this issue. In fact, of the two derived tones, only rising tones were recorded and analysed in this study. We will have little to say about these contour tones, however. Since verbs in the language are predominantly monosyllabic and contour tones arise on mostly polysyllabic words other than

[3] This is analogous to the effects of depressor consonants, in which voiced obstruents block the spreading of H tones.

verbs, derived tones play no significant role in the phenomenon under investigation.

2.2 Preservation of lexical tone

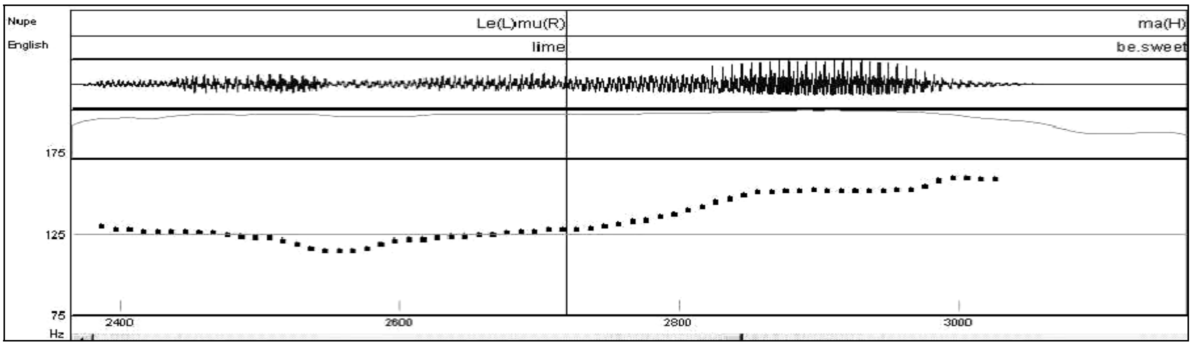
Before we can determine whether or not the verbs participating in Nupe verb doubling constructions are specified for the same tones phonologically, we must know *if* and *how* the appropriate measurements can be taken to yield a result. This subsection and the subsequent ones all address this issue.

Our initial question is whether or not we can simply compare direct measurements of the f0 values of V1 and V2 in verb copy constructions. Various factors might prohibit such a methodology, the most notable being the influence of intonation on lexical tone. In addition to any of a number of "local" phenomena which although relatively easy to control for, may also affect the realization of a given underlying tone (i.e. microprosody (Peterson & Barney (1952), Silverman (1997)); tonal coarticulation (Lea (1973)); declination (Pierrehumbert & Beckman (1988)); and downdrift (Hombert (1974), Laniran (1992))), lexical tone can be overridden by sentence-level prosodic phenomena such as pitch-accentation (Jin (1996)) and final lowering/intonation phrase (IP) boundary tones (Newman & Newman (1981), Pierrehumbert & Beckman (1988), Herman (1996)), which do not always prove easy to factor out. If such factors play a prominent role in the realization of tone in Nupe, it will not be possible to directly compare the tones on verbs in verb doubling constructions. Fortunately, this is not the case. The following data suggest that lexical tone is preserved in the language. In what follows, most of the potential "local" confounding factors mentioned above were controlled for (with the exception of tonal articulation). Additionally, Nupe is not a pitch-accent language.

(5) a. Pitch-track for the Nupe sentence:

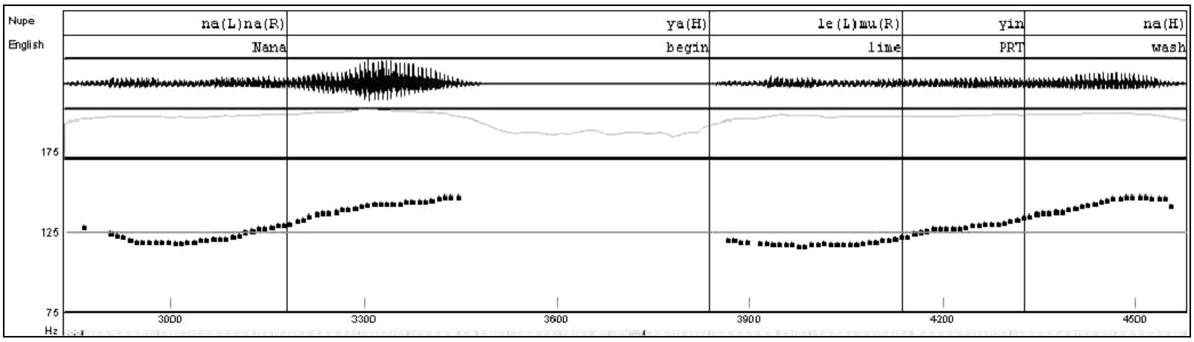
[Lèm`ú má]$_{IP}$[4]
lime be sweet
'The limes are sweet.'

[4] The bracketing in the example sentences above each pitch-track in this paper reflects the prosodic constituency of the particular utterance, which will be argued for in §2.3.2. "IP" here is an abbreviation for 'intonation phrase' and "ip" abbreviates 'intermediate (phonological) phrase'. Labels for prosodic constituents appear immediately below and to the right of the phrase they demarcate.



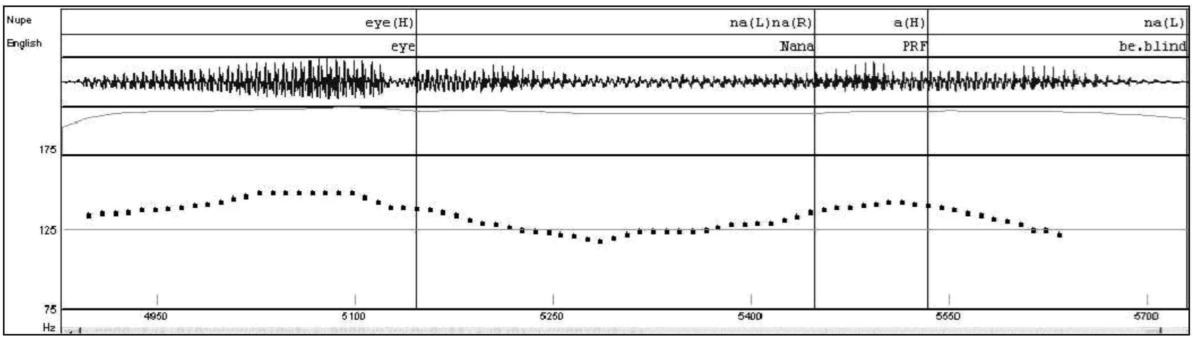
b. Pitch-track for the Nupe sentence:

[[Nàn`á yá]$_{ip}$ [lèm`ú yin ná]$_{ip}$]$_{IP}$
Nana begin lime PRT wash
'Nana began to wash the limes.'



c. Pitch-track for the Nupe sentence:

[Eyé Nàn`á á nà]$_{IP}$
eye Nana PRF be blind
'Nana is blind.'



(5a) illustrates that IP boundaries in simple Nupe declarative sentences are not marked with boundary tones as they are in many languages (such as L% in English (Pierrehumbert (1980))). The underlying tone sequence of L-Rise-H (as observed for each respective word in isolation) is faithfully preserved in the prosodic structure. We find a similar pattern in (5b), although the utterance is longer, syntactically more complex and consists of two intermediate (phonological) phrases.[5] (Note that for this speaker, rising tones appear to be L-M sequences, as opposed to the L-H contours previously described for the language and represented in the orthography. We will see more data supporting this observation as we analyse further Nupe sentences.) Example (5c) further illustrates the faithful surfacing of lexical tones in simple declarative sentences, but with a different sequence. We conclude that at least in simple declarative sentences, underlying tones in Nupe are fully realized and not influenced by intonational effects. Thus, the direct measurement of the fundamental frequency values of participating verbs in verb doubling constructions seems like a promising methodology.

2.3 Nupe intonation phrases

In this subsection, we take a closer look at intonation phrases and IP boundaries in the language. Our previous assessment of Nupe IP boundary phenomena was confined solely to simple declarative sentences. However, verb copy constructions clearly do not fall under this rubric. We begin by considering IP boundary phenomena in these constructions, with particular attention to the right-edge of the utterance. We then consider whether Nupe has utterance-internal IPs and whether this has any consequences for the enterprise of determining the identity of the tones on the verb and its copy in verb doubling constructions.

2.3.1 A closer look at Nupe intonation phrase boundary phenomena. In the last section, we observed that the lexical tones of verbs (among others) are preserved at the intonation phrase boundaries in simple declarative sentences (cf. (5a-c)). The typical position of the second verb in a doubling construction is also at the right edge of an IP boundary (cf. (1)).[6] We might wonder then whether lexical tones are preserved in this context as well. The following data seem to suggest that underlying H tones do not surface as such in verb doubling constructions.

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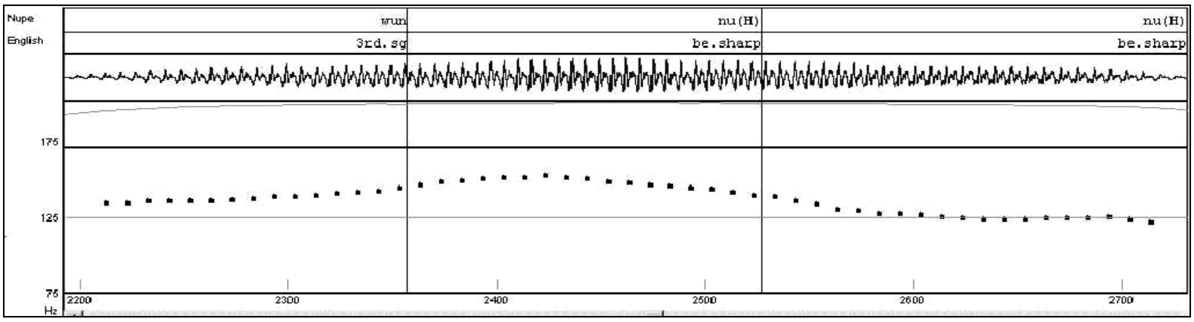
[5] We address the issue of distinguishing intermediate (phonological) phrases from full intonation phrases in Nupe in the following subsection.

[6] V2, however, may be followed by embedded clauses or adjuncts that may or may not constitute separate IPs.

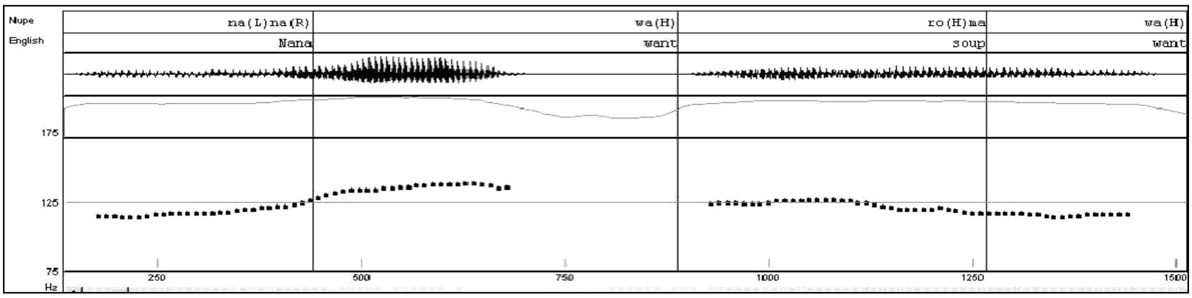
(6) a. Pitch-track for the Nupe sentence:

[Wun nú nú]$_{IP}$
3rd sg be sharp be sharp
'Is it sharp?'



b. Pitch-track for the Nupe sentence:

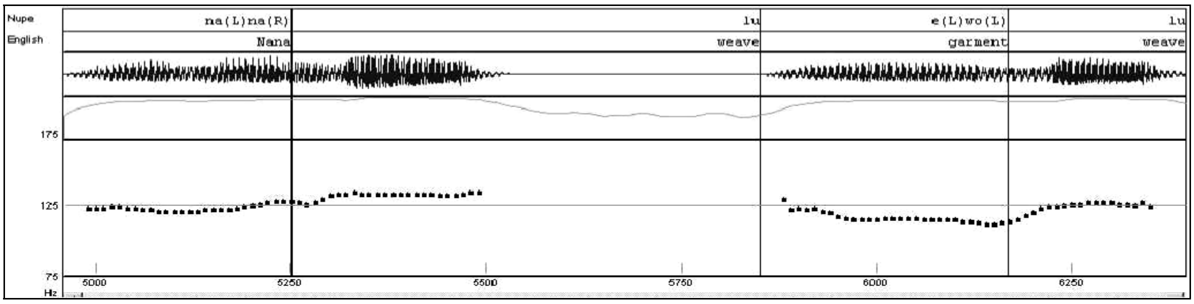
[[Nàn`á wá]$_{ip}$ [róma wá]$_{ip}$]$_{IP}$
Nana want soup want
'Nana DOES want soup.'



The f0 value of the first token of the verb in (6a) is almost 40Hz greater than the second token. Furthermore, the f0 value of V2 in the same sentence is lower in frequency than the sentence-initial pronoun, which is underlyingly a M tone. Similar facts obtain in (6b) as well. V2 is clearly within the L tone range, as can be observed upon comparison with the f0 value of the initial L tone on the subject. Consider next the case of M tones at verb doubling IP boundaries.

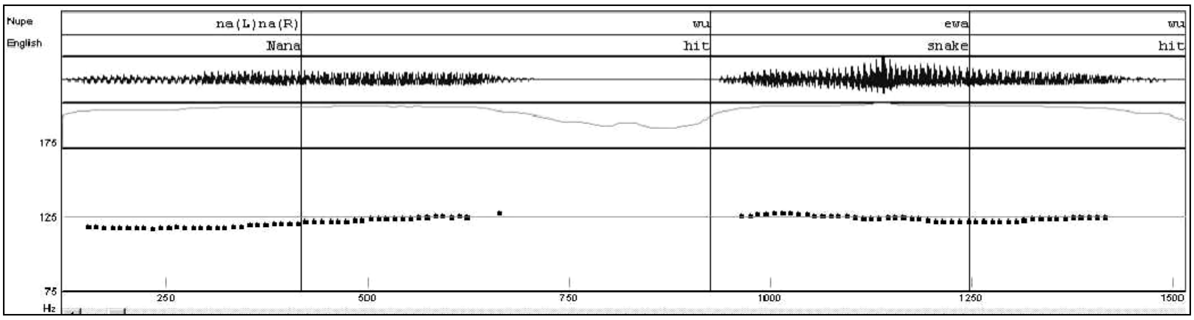
(7) a. Pitch-track for the Nupe sentence:

[[Nàn`á lu]$_{ip}$ [èwò lu]$_{ip}$]$_{IP}$
Nana weave garment weave
'Nana DID weave a garment.'



b. Pitch-track for the Nupe sentence:

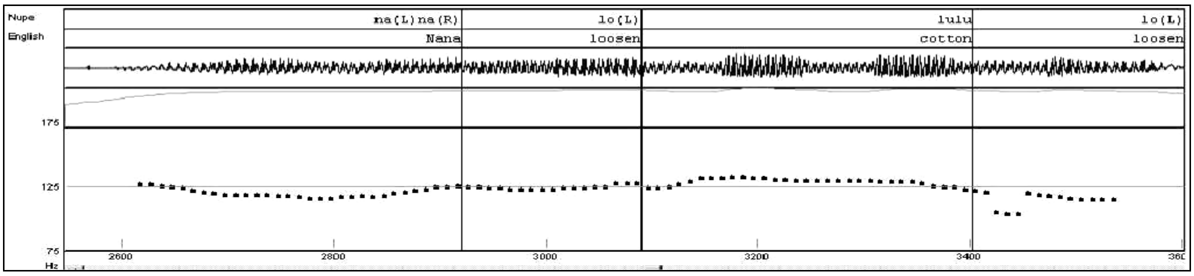
[[Nàn`á wu]$_{ip}$ [ewa wu]$_{ip}$]$_{IP}$
Nana hit snake hit
'Nana DID hit a snake.'



Although the f0 value of V1 is slightly greater than that of V2 in (7a) (about 5Hz greater), the values of both verbs look nearly identical in (7b). Furthermore, the tone on V2 is produced at a higher frequency than the initial L tone on the subject in (7b). However, without independently knowing the tonal ranges of this speaker for each category, it is not clear at this point whether to count the second token of the verb as bearing a M or L tone (especially in the case of (7a) where the tone on V2 is produced with a lower frequency than that of V1, but with a frequency nearly equal to that of the L tone-bearing sentence-initial syllable). So, it is presently difficult to tell whether M tones are preserved at IP boundaries in verb doubling constructions. Fortunately, the data involving L tones at verb doubling IP boundaries is easier to interpret. Consider the following example.

(8) Pitch-track for the Nupe sentence:

[Nàn`á lò lulu lò]$_{IP}$
Nana loosen cotton loosen
'Nana DID loosen the cotton.'



Because V2 is produced with a lower frequency than the other L tone-bearing verb in the sentence, it is unproblematic to claim that at the very least, underlying L tones are not raised at IP boundaries in verb doubling constructions. Although it *could* turn out to be the case that they are slightly lowered in this environment, it seems as though lexical L tones are preserved at verb doubling IP boundaries. We will take a closer look at this in section three.

Taking stock of what we've observed thus far, it seems that underlying H tones do not surface as H at the IP boundaries of verb doubling constructions. L tones, on the other hand, appear to surface as L in the same environment. More problematic are the M tones, which do not provide us with a clear-cut interpretation of the observed facts. Nonetheless, there are two possible ways to account for the data previously presented. The first possibility is that at the level of intonational phonology, verb doubling constructions are distinguished from simple declarative sentences in that the former are marked by low IP boundary tones (L%) which override lexical tone (cf. the phenomenon of optional L% in Hausa Yes/No questions (Newman and Newman (1981), Inkelas and Leben (1991)). On this view, we may expect underlying M tones at verb doubling IP boundaries to be realized as L tones. Given the proper amount of data and analysis, this claim is easily falsifiable. This intonation-based account contrasts with a second and purely phonological way of interpreting the data. On this approach, there is a phonological rule that specifically shifts underlying H tones at verb doubling IP boundaries to surface as L tones. This phonological rule overrides the preservation of lexical H tones at the IP boundaries of verb doubling constructions, but does not affect the preservation of M or L tones. Thus, this account can be falsified by the finding that underlying M tones at verb doubling IP boundaries do in fact surface as L tones.

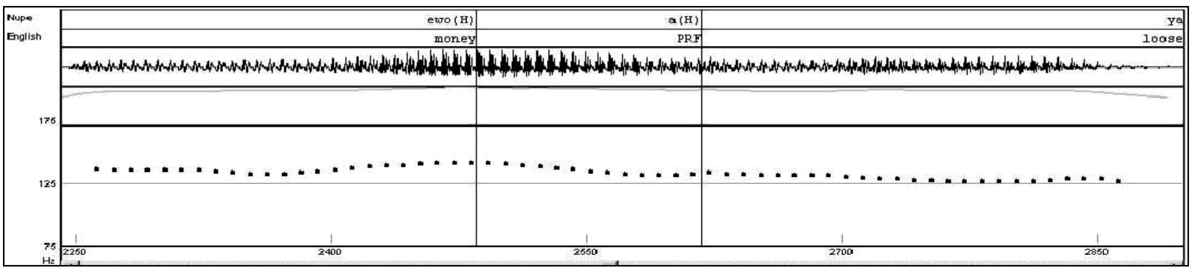
The upshot of this discussion is threefold. First, it is clear that unless our data is inaccurate, some boundary phenomenon is active in Nupe verb doubling constructions. Second, uncovering the precise nature of this phenomenon requires more than the visual inspection of a few pitch-tracks. Later in this paper, we will present the results of an experiment designed to determine which of the two analyses previously offered (if any) is most likely to be correct. And third, regardless of the nature of this boundary phenomenon, when investigating the tonal identity of the verb and its copy in a given doubling construction, we must consider only those sentences in which V2 is non IP-final.

2.3.2 A closer look at Nupe intonation phrases. So far, we have been limiting our attention to utterance-final intonation phrases/boundaries. However, utterance-internal IPs are well attested in the languages of the world. Are such phrases part of the prosodic structure of Nupe? With respect to the examples we have looked at, (5b), (6b), and (7a,b) clearly show signs of a prosodic phrase division internal to the utterance. In all these examples, there is a pause of roughly 300-600 milliseconds separating the second word (a verbal element) from the remainder of the utterance. Still, it is not quite clear whether this boundary is a true intonation phrase boundary or merely an intermediate (phonological) phrase boundary. However, one clue suggesting that the boundaries in these data are not true IP boundaries is the fact that unlike at the right-edges of verb doubling constructions, lexical tones are preserved in these contexts (especially H tones).

One property that often distinguishes intonation phrases from intermediate (phonological) phrases is pitch-reset. Following the pause at a true intonation phrase boundary, the speaker's pitch register is reset, and as a consequence, f0 values following the boundary are initially higher than the values of the preceding neighbouring tones. This is best observed in cases where H tones surface flanking the boundary (as will I show in (26), M and L tones tend to span narrower f0 ranges and thus vary less drastically than H tones). Looking at (6b), we find that the H following the prosodic break was produced with a noticeably lower frequency than the preceding one. In this case, we can attribute the lower f0 value of this tone to the phenomenon of pitch declination. Observe that the degree of pitch declination (drop in pitch) in (6b) is similar to the degree of declination in cases where the two tones are clearly within the same prosodic phrase (i.e. not separated by a pause).

(9) Pitch-track for the Nupe sentence:

[Ewó á ya]$_{IP}$
money PRF loose
'The money is lost.'

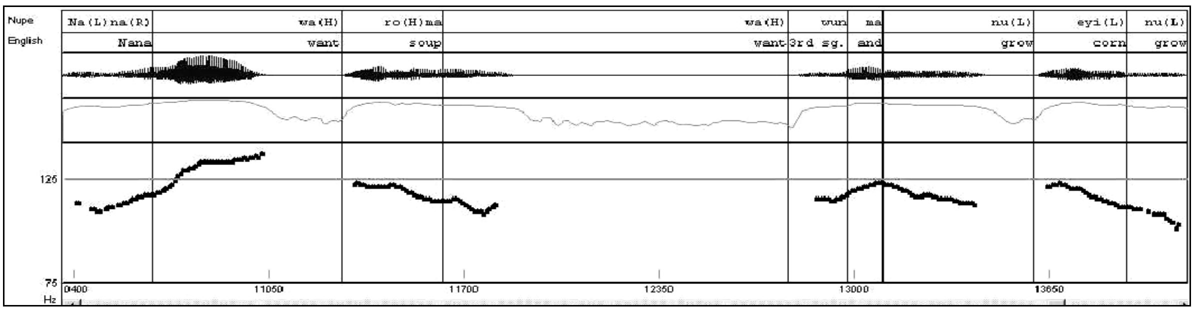


If the portion of the utterance following the pause in (6b) constituted a separate prosodic domain, we would not expect the f0 value of the vowel following the break to be influenced by material preceding the break. We can also account for the fact that the f0 values following the breaks in (5b) and (7a,b) are so similar to those either in utterance-initial position (as is the case in (5b) and (7a)) or to those immediately preceding it (as is the case in (7b)) by appealing to intermediate phrase boundaries and the finding that the rate of pitch declination for M and L tones in the language is significantly lower than for H tones. (This is independently established in section four.) Thus, we have every reason to believe that although intermediate phrases are attested, they do not constitute boundary tone-bearing prosodic domains in the language. Moreover, the domain of declination seems to be larger than such phrases. Unlike the case of utterance-final verbs in doubling constructions, then, we needn't avoid utterances with such prosodic structures in our investigations.

Although we haven't found evidence for true utterance-internal IPs in the language, that doesn't mean there aren't any. At the very least, coordinate structures admit of utterance-internal IPs as well as intermediate (phonological) phrases. Each coordinate represents a unique prosodic domain, as the following pitch-track shows.

(10) Pitch-track for the Nupe sentence:

[[Nàn`á wá]$_{ip}$ [róma wá]$_{ip}$]$_{IP}$ [[wun ma nù]$_{ip}$ [eyì nù]$_{ip}$]$_{IP}$
Nana want soup want 3rd sg and grow corn grow
'Nana DID want soup and she DID grow corn.'



Evidence that each conjunct represents a unique prosodic domain comes from the fact that the underlying H tone on V2 surfaces rather low in conjunct one, as per our observation in section 2.3.1. Additionally, the fact that the f0 value of *wun* is greater than the f0 value *wá*, suggests that pitch-reset has occurred. So although V2 is non sentence-final in coordinate structures, it is IP-final. Therefore, given our informal observations about IP boundary phenomena in verb doubling constructions from the preceding sub-section, we must also be cautious of conjunct-final environments when investigating the tonal identity of the verb and its copy.

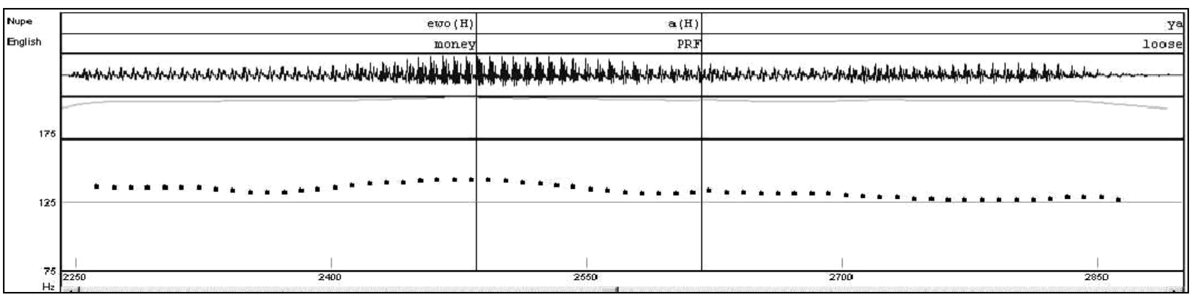
2.4 Factors causing intra-categorial f0 variation in Nupe: pitch declination and tonal coarticulation

In the previous subsection, we speculated that the phonetic phenomenon of pitch declination may be responsible for lowering the f0 values on subsequent syllables of the same underlying tonal category (even across intermediate (phonological) phrase boundaries). Here, we attend to this speculation and also consider whether other factors play a role in f0 value variation within a given tonal category in the language.

Pitch declination refers to the phenomenon whereby f0 values within a particular tonal category tend to proportionately decrease over the length of the utterance or within the IP. It has been observed that declination rates vary within the utterance (Shih (2000)), across tonal categories (Laniran (1992)), and from language to language (Shih (2000)) as well as from speaker to speaker. Although there are many theories of pitch declination, the insight that it is caused by decreasing subglottal pressure (Titze (1989)) seems to form the core notion on many accounts. We can clearly observe that pitch declination affects surface f0 values in Nupe by considering the surface realization of consecutive syllables specified for the same underlying tone. The data below illustrates this for sequences of two adjacent underlying H tones.

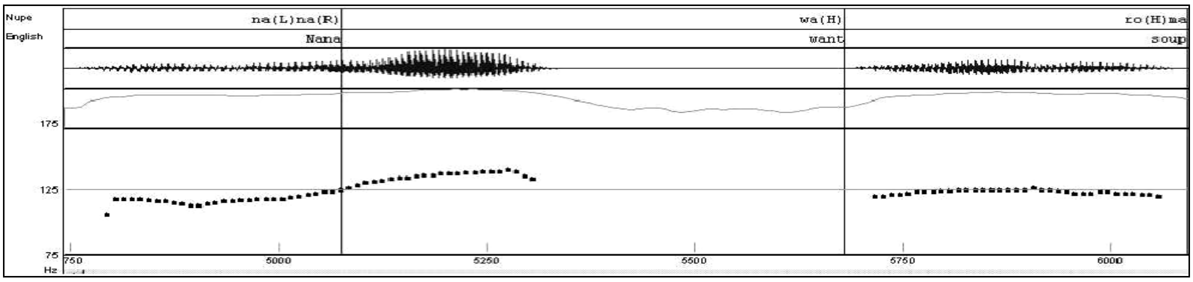
(11) a. Pitch-track for the Nupe sentence:

[Ewó á ya]_{IP}
money PRF loose
'The money is lost.'



b. Pitch-track for the Nupe sentence:

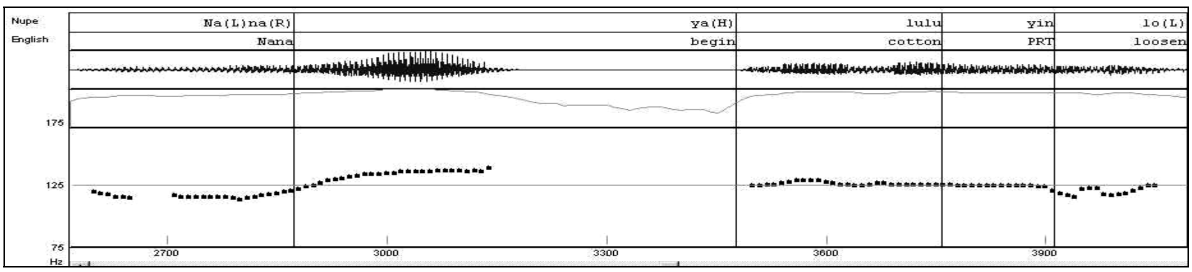
[[Nàn`á wá]$_{ip}$ [róma]$_{ip}$]$_{IP}$
Nana want soup
'Nana wanted soup.'



In (11a), the second H tone is produced approximately 10Hz lower than the initial H. Although we might expect the second tone to be slightly lower than the first given the fact that the first tone is realized on a mid vowel ([o]), whereas the second is realized on a low vowel ([a]), the data in (11b) shows that decreasing f0 values on adjacent syllables cannot be solely due to vowel height. In this pitch-track, we find a difference of approximately 15Hz, but in this case, the low vowel precedes the mid vowel. Consider next, the following pitch-tracks illustrating sequences of three and four adjacent underlying M tones respectively.

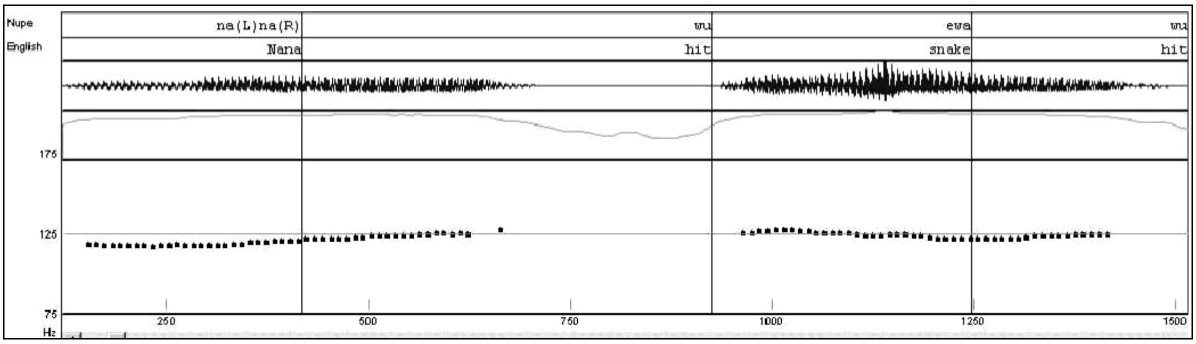
(12) a. Pitch-track for the Nupe sentence:

[[Nàn`á yá]$_{ip}$ [lulu yin lò]$_{ip}$]$_{IP}$
Nana begin cotton PRT loosen
'Nana began to loosen the cotton.'



b. Pitch-track for the Nupe sentence:

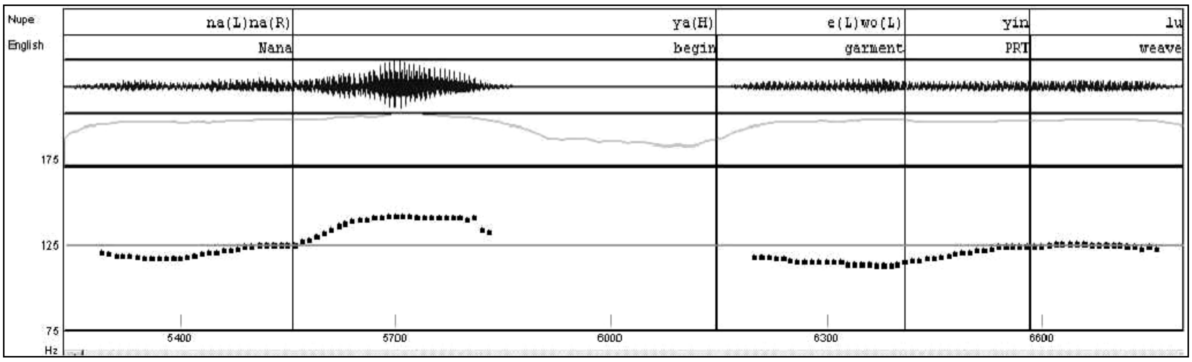
[[Nàn`á wu]$_{ip}$ [ewa wu]$_{ip}$]$_{IP}$
Nana hit snake hit
'Nana DID hit the snake.'



These data show that although the effect of pitch declination is substantial within category H, it is minimal for category M (f0 values of subsequent syllables differ from the values of preceding syllables of the same underlying tonal category by only a few hertz). The following pitch-track illustrates that the effect of L tone declination is less extreme than for H, but more prominent than in category M.

(13) Pitch-track for the Nupe sentence:

[[Nàn`á yá]$_{ip}$ [èwò yin lu]$_{ip}$]$_{IP}$
Nana begin garment PRT weave
'Nana began to weave a garment.'



We can also observe that neighbouring tones influence surface f0 values, similar to the way pitch declination causes intra-categorial f0 variation. This phenomenon, known as tonal coarticulation, can be observed in many of the preceding pitch-tracks. For example, (5c) shows that when immediately following a H tone, a L tone surfaces with a slightly higher f0 realization. If we consider examples in which the third syllable within the IP surfaces with a L tone (cf. (8) & (10)), we find that typical f0 values are less than 125Hz (considerably less, in the case of IP #2 in example (10)). However, in (5c), the f0 value measured in the middle of the vowel is clearly greater than 125Hz. In general, the surface realization of a tone is partly influenced by the surface realization of the preceding tone. In many cases as well, surface tonal realizations are shaped by following tones. Thus, in addition to pitch declination, the phenomenon of tonal coarticulation plays a role in the intra-categorial variation of f0 values in Nupe tones.[7] Given these factors, as well the potential boundary phenomena observed for verb doubling constructions in the previous subsection, we should expect at least a modest degree of variation with respect to the f0 values of the verbs participating in verbal copy constructions (especially if they are separated from each other by several syllables). Before formally investigating the central issue of the categorical identity of the tone on the verb and the tone of its copy in a given doubling construction, let's informally consider whether our expectations in this respect are met.

2.5 A preliminary look at the tonal properties of V1 and V2 in Nupe verb copy constructions

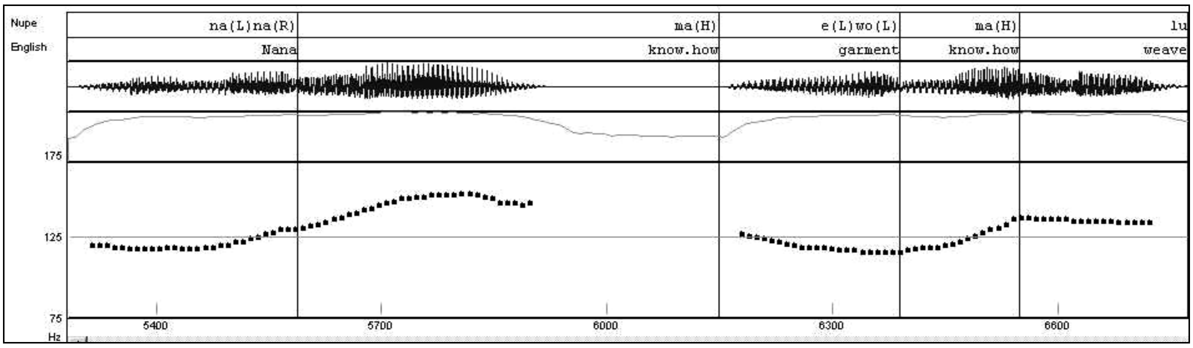
In the previous subsection, we observed that within the IP various factors conspire to cause f0 values within tonal categories to vary, and that as a result we should expect a certain degree of variation with respect to the f0 values of verbs in verb doubling constructions. Despite this expectation, we might be surprised to find that the extent of this variation is quite substantial, even when we control for the effects of IP boundary phenomena in such sentences. The following pitch-tracks show that with respect to verbs lexically specified for H tones, the difference in fundamental frequency between V1 and V2 is rather significant. In fact, the production of the tone on V2 is so different from that of V1 that it might be tempting to claim that V1 and V2 do not belong to the same tonal category at all.

(14) a. Pitch-track for the Nupe sentence:

[[Nàn`á	má]$_{ip}$	[èwò	má	lu]$_{ip}$]$_{IP}$
Nana	know	garment	know	weave

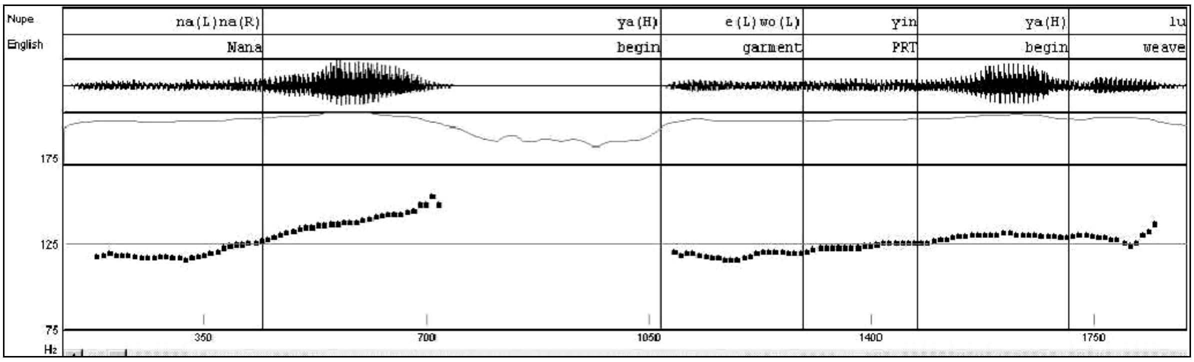
'Nana DOES know how to weave garments.'

[7] A third factor that may cause further variation in f0 values within a particular category is the phenomenon of downdrift. Downdrift is the phenomenon in which the second H in a sequence HLH is produced with a considerably lower f0 value than the first H and whose effect cannot entirely be the result of pitch declination, but rather due mainly to the conditioning of the preceding L. This phenomenon is attested in the closely related language Yoruba (Laniran (1992)); however, we do not have enough data at this time to determine whether it is attested in Nupe as well. Thus, the data we will consider in this paper are free from the environments that trigger the phenomenon.



b. Pitch-track for the Nupe sentence:

[[Nàn`á yá]$_{ip}$ [èwò yin yá lu]$_{ip}$]$_{IP}$
Nana begin garment PRT begin weave
'Nana DID begin to weave garments.'



Nonetheless, speakers perceive the tonal categories of V1 and V2 to be identical. How can we reconcile the fact that at least with respect to verbs lexically specified for H tones, speakers interpret the tonal categories of the verb and its copy to be *phonologically* identical despite the fact that they are *phonetically* non-identical?[8] To do so, we will need to adopt a more quantitative approach. We turn to this task in the next section.

2.6 Our preliminary observations in summary

In this section, we observed that because lexical tone is not in general overridden by intonational phenomena, we will be able to directly compare measurements of fundamental frequency for both verbs in verb doubling constructions. However, we saw that at the IP boundaries of verb copy constructions lexical H tones do not appear to faithfully surface as such. Although we were unable to informally determine whether the phenomenon is truly characteristic of IP boundaries in verb

[8] In essence, this is the general problem of abstract phonological categories.

doubling constructions in general, we concluded that in order to play it safe when analysing verb doubling constructions we should not consider sentences in which V2 is IP-final. In section three, we will conduct an experiment to determine whether the boundary phenomena we observed in verb copy constructions is purely phonological or whether it belongs to the domain of intonational phonology. We also observed that in addition to intonation phrases, Nupe makes use of smaller prosodic units we called intermediate (phonological) phrases. We saw that although pitch reset does not occur across these boundaries, phenomena such as pitch declination and tonal coarticulation do. It was shown that the latter two phenomena (especially pitch declination) can cause fairly substantial f0 variation within certain tonal categories. Given this, it will be important to calculate the rate of pitch declination for each tonal category when determining whether the tonal category of V1 is identical (in the phonological sense) to the tonal category of V2. This is carried out in section four. Finally, we observed that once we take pitch declination and tonal coarticulation into consideration and factor out the seeming IP boundary phenomena in verb doubling constructions, the surface tonal realization of V2 is surprisingly different from the realization of V1 in the case of verbs lexically specified for H tones. In section five, we will provide a more rigorous quantitative analysis of the tonal realizations of both verbs in verb doubling constructions and conclude that although phonetically non-identical, the tonal categories of the verb and its copy are phonologically identical, as perceived by native speakers.

3 Experiment 1: IP boundary tone-shift in verb doubling constructions

In section 2.3.1, we observed that H tones at the IP boundaries of verb doubling constructions seem to be realized with f0 values canonically lower than for typical Hs. In this experiment, we are interested in determining whether the phenomena we observed is indeed characteristic of IP boundaries in such constructions. In the event that this is the case, we would also like to know whether all tones are lowered at the IP boundaries in such constructions (i.e. whether verb doubling IP boundaries are characterized by a L% in the intonational phonology) or whether only H tones are affected (i.e. whether there is a purely phonological rule in Nupe that shifts H tones at verb doubling IP boundaries to L tones). The outcome of this experiment will prove important to the methodology of our main investigation. If it turns out that the boundary phenomena we observed in verb doubling constructions is truly characteristic of IP boundaries in such sentence types, our analysis must exclude data in which V2 is IP-final. However, if our findings lead us to a contrary conclusion, the restrictions on our data set will be minimal.

3.1 Methods

The speech of a male native speaker of Nupe in his thirties was recorded and analyzed. The subject was recorded digitally in a soundproof booth at the UC Berkeley phonetics and phonology laboratory in the summer of 2003. A script of Nupe test sentences was prepared by the experimenter and previewed by the subject prior to recording for familiarity. These sentences were constructed using only sonorants and vowels in order to avoid the effects of microprosody and yield uninterrupted pitch-tracks. Various types of sentences were elicited and for each distinct sentence type, its corresponding verb doubling counterpart was collected. The data were elicited in a randomised order to counter list effects. During the recording, the subject produced three tokens of each sentence (with sizeable pauses between each token). Fifty-seven sentences were recorded with three tokens per sentence, making the total number of recorded utterances one hundred seventy one. In this experiment, twenty sentences were discarded due to excessive creakiness at the IP boundaries. The total number of utterances analysed was thus one hundred fifty one. The data was analysed in the UCLA phonetics laboratory using Pitchworks (Scicon R&D, Inc. (2003)), a pitch-tracking software program. Measurements of f0 values for H tones were made at the peak frequencies of the vowel detected by Pitchworks. M and L tone f0 values were measured in the middle of the vowels. In order to determine whether the verb doubling boundary phenomena previously observed is real, the f0 values of sentence-final (IP-final) verbs in both declarative and doubling sentences for all tonal categories were collected and compared. For each recorded sentence, the measurements of the three token utterances were collapsed into one value by taking their mean. This was done in order to insure that each individual observation was not treated as statistically independent. A two-factor ANOVA was then performed on the collected data to determine whether the surface realization of tones at Nupe IP boundaries is determined by syntactic structure (declarative vs. verb doubling). Additionally, a one-factor non-repeated measure ANOVA was carried out to determine whether for each tonal category the f0 values of tones at IP boundaries in doubling sentences are significantly different than the f0 values of tones at IP boundaries in simple declarative sentences.

3.2 Results

The descriptive statistics for the f0 values of IP-final verbs in both declarative and doubling constructions for each tonal category are provided in the table below.

(15)

CONSTRUCTION, UNDERLYING TONE	COUNT	MEAN	STD. DEV	STD. ERROR
Declarative, H	12	152.417	2.644	0.763
Declarative, M	27	128.852	4.148	0.798
Declarative, L	21	118.476	4.297	0.938
Doubling, H	36	120.833	5.353	0.892
Doubling, M	30	131.633	4.247	0.775
Doubling, L	25	115.680	3.761	0.752

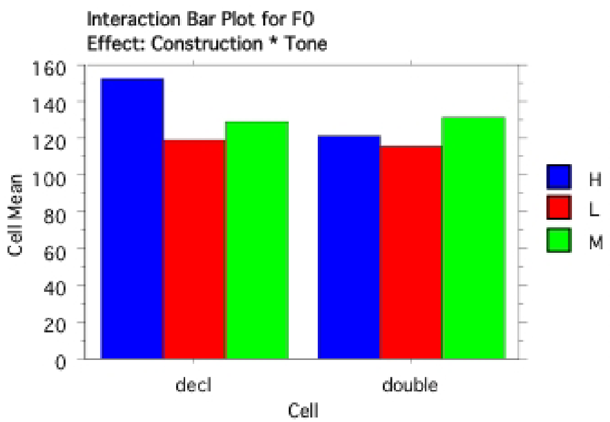
The results of a two-factor ANOVA show that there are significant main effects of construction (declarative vs. doubling) and tone (H,M,L), as well as significant interaction between the two. These results are presented below.

(16) ANOVA table for f0 × syntactic construction

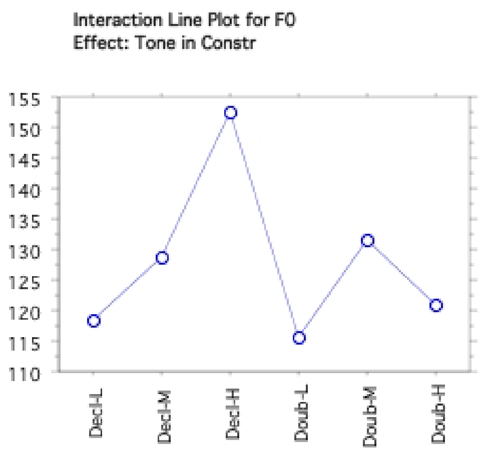
	DF	SUM OF SQUARES	MEAN SQUARE	F-VALUE	P-VALUE
Construction	1	602.66	602.66	32.41	< 0.0001
Tone	2	1867.29	933.64	50.22	< 0.0001
Construction × Tone	2	2335.80	1167.90	62.81	< 0.0001
Residual	145	836.68	18.59	-	< 0.0001

The interaction graphs in (17) show that f0 values for H tones at IP boundaries in verb doubling constructions are considerably lower than in declaratives. Nonetheless, the average values of M and L tones respectively surface with similar values regardless of construction type.

(17) a.



b.



In order to investigate whether M and L tones are not statistically different in the two constructions and whether the IP-final H tone in doubling constructions is similar to or different from other tone categories, a one-factor ANOVA was performed by combining two factors, creating six categories (i.e. three tones × two construction types). The results are presented below.

(18) Scheffe post-hoc analysis – effect: tone in construction (sig. level: 5%)

	LOWER	MEAN DIFFERENCE	UPPER	P-VALUE	
Declarative-L, Declarative-M	-17.94	-10.38	-2.81	<0.05	S
Declarative-L, Declarative-H	24.54	33.94	43.35	<0.05	S
Declarative-L, Doubling-L	-5.01	2.55	10.11	>0.05	
Declarative-L, Doubling-M	-20.55	-13.16	-5.76	<0.05	S
Declarative-L, Doubling-H	-4.78	2.36	9.49	>0.05	
Declarative-M, Declarative-H	14.55	23.56	32.58	<0.05	S
Declarative-M, Doubling-L	-20.00	-12.93	-5.85	<0.05	S
Declarative-M, Doubling-M	-9.68	-2.78	4.11	>0.05	
Declarative-M, Doubling-H	-14.64	-8.02	-1.40	<0.05	S
Declarative-H, Doubling-L	27.47	36.49	45.51	<0.05	S
Declarative-H, Doubling-M	11.91	20.78	29.66	<0.05	S
Declarative-H, Doubling-H	22.92	31.58	40.25	<0.05	S
Doubling-L, Doubling-M	-22.60	-15.71	-8.81	<0.05	S
Doubling-L, Doubling-H	-1.71	4.91	11.52	>0.05	
Doubling-M, Doubling-H	-17.23	-10.80	-4.37	<0.05	S

The results show that there is a significant main effect of the combined category. In particular, the data shows that each of the six tonal categories (Declarative-L, Declarative-M, Declarative-H, Doubling-L, Doubling-M, Doubling-H) are different from one another, except for four comparisons (i.e. Declarative-L vs. Doubling-L, Declarative-M vs. Doubling-M, Declarative-L vs. Doubling-H, and Doubling-L vs. Doubling-H). This confirms that the IP-final H tone in the doubling construction is different from M or H tones regardless of construction type and that it is not statistically different from IP-final L-tones in both declarative and doubling sentences.

3.3 Discussion

It is clear from the results of this experiment that a) there are at least three distinct surface tones in Nupe (H,M,L) and b) the shifting of underlying H tones at verb doubling IP boundaries is indeed characteristic of the construction. V2 in this environment was on average produced 30Hz lower than V1 across thirty-six utterances. The post-hoc results in (18) show that in this environment, underlying H tones surface categorically as L tones. The table shows that that the f0 values of underlying H tones in verb doubling constructions are significantly different from the values of underlying H tones in declaratives. Furthermore, the f0 values of underlying H tones in verb doubling constructions are not significantly different from the f0 values of underlying L tones in simple declarative sentences. To complete the argument that underlying H tones surface as L tones at the IP boundaries of verb doubling constructions, we note that the f0 values of underlying H tones at IP boundaries in verb doubling constructions are not significantly different from the f0 values of underlying L tones at IP boundaries in verb doubling constructions. This finding completes the argument because it abstracts away from the effect of construction type in determining surface f0 realization of H tones (as we established in the previous subsection).

But what about M and L tones? The results of the post-hoc test presented in (18) suggest that their categorical realization is not affected by construction type. That is, whereas underlying H tones are phonologically realized as L tones at verb doubling IP boundaries, underlying M and L tones are realized as mid and low tones respectively in this environment (cf. lines eight and three in (18)). Because underlying M tones do not surface as L tones in this environment, we have evidence that the lowering of H tones at verb doubling IP boundaries is not due to the presence of low boundary tones (L%) in this type of construction. Instead, the proper analysis of H-tone lowering at Nupe verb doubling IP boundaries seems to be the purely phonological account in which underlying H tones are specifically targeted and shifted to L tones at verb doubling IP boundaries. We are silent, however, on why Nupe disprefers IP-final H tones in verb doubling constructions.[9] Given these findings, we conclude that when comparing the surface tonal

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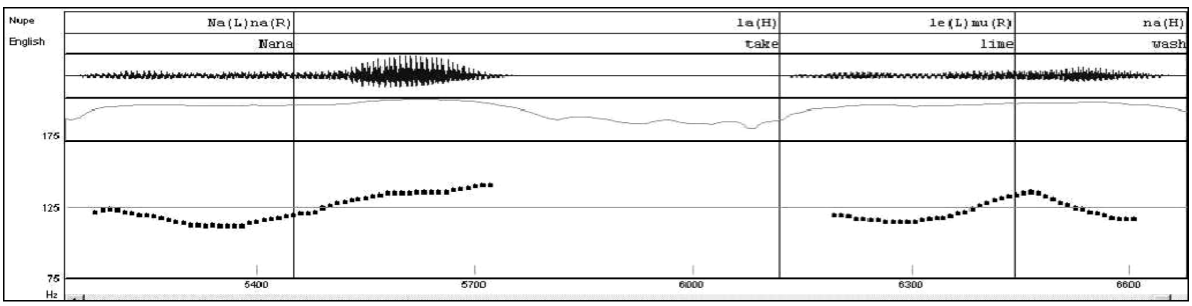
[9] This pattern of tone shifting does not seem to be unique to verb doubling constructions in the language. It appears that this also happens at the IP boundary in serial verb constructions as shown in the following:

(i) Pitch-track for the Nupe sentence:

[[Nàn`á lá]$_{ip}$ [lèm`ú ná]$_{ip}$]$_{IP}$
Nana take lime wash
'Nana took the lime and (then) washed it.'



Unfortunately, due to limited data, this parallel cannot be firmly established. We leave this for future research as well.

realizations of the verbs in verb copy constructions we must exclude data in which V2 occurs in IP-final position. This includes environments within coordinate structures as well as utterance-final contexts, but not intermediate (phonological) phrases because they do not exhibit similar boundary phenomena (c.f. (10)).

4 Experiment 2: rate of pitch declination in Nupe

In section 2.4, we noticed that to some extent the phenomenon of pitch declination contributes to variation in fundamental frequency values within tonal categories. We also took note of the fact that H tones appeared to be more drastically affected by the phenomenon than M or L tones. Given that we are interested in determining whether the tonal categories of the participating verbs in Nupe verb doubling constructions are phonologically identical, it is important to have a precise understanding of the factors responsible for intra-categorial f0 variation in the language. In this section, we investigate the phenomenon of pitch declination in Nupe, in particular, the rate of pitch declination for two adjacent syllables in all three tonal categories.

4.1 Methods

The subject used in the previous experiment was also the subject of this study. For this experiment, no new utterances were recorded. Instead, the one hundred seventy one previously recorded sentences were examined and measurements were made of the f0 values of adjacent syllables underlyingly specified for the same tonal category using Pitchworks. Data with broken (non-continuous) pitch-tracks were discarded. Measurements of vowels with H tones were made at the f0 peaks, while measurements for M and L tones were made in the middle of the vowel. Only IP-internal sequences of adjacent syllables with like tones were measured. Neither of the two syllables measured was situated at a major IP boundary, however, in certain cases one of the syllables fell at an intermediate (phonological) phrase boundary. Given that pitch-reset does not occur at intermediate phrase boundaries in Nupe (cf. example (10) §2.3.2), such measurements are unproblematic. The environment in which the adjacent syllables were measured was not held constant in this experiment. As a result, the measurements were made at various points across utterances of varying length. Although the rate of pitch declination is known to vary over the course of an utterance (f0 decline is more pronounced at the outset of the utterance and slows down as the sentence progresses (Cooper & Sorensen (1981), Shih (2000)), declination rates do not vary as a function of sentence length (Shih (2000)). A considerable number of measurement pairs for each tonal category were made at virtually all points within the IP boundaries (one hundred forty three pairs of measurements, in total) in order to combat the lack of a uniform environment for measuring the tones on adjacent syllables. Thus, since a significant number of measurements spanning all environments within the IP were made, the mean values of the resulting measurements can be used to calculate the average rate of pitch declination for a given tonal category.

The results of this experiment are highly simplified. We arrive at a value for a rate of pitch declination that is valid only for sequences of two adjacent like-tones and whose value is not a function of time. This is primarily due to a lack of data involving sequences longer than three adjacent like tones in length. Further research and substantially more data are necessary to develop a more proper characterization of the rate of declination in Nupe. Nonetheless, the simplified findings presented in this section are enough to establish the categorical tonal identity of both the verb and its copy in verb doubling constructions (as we will show in section five).

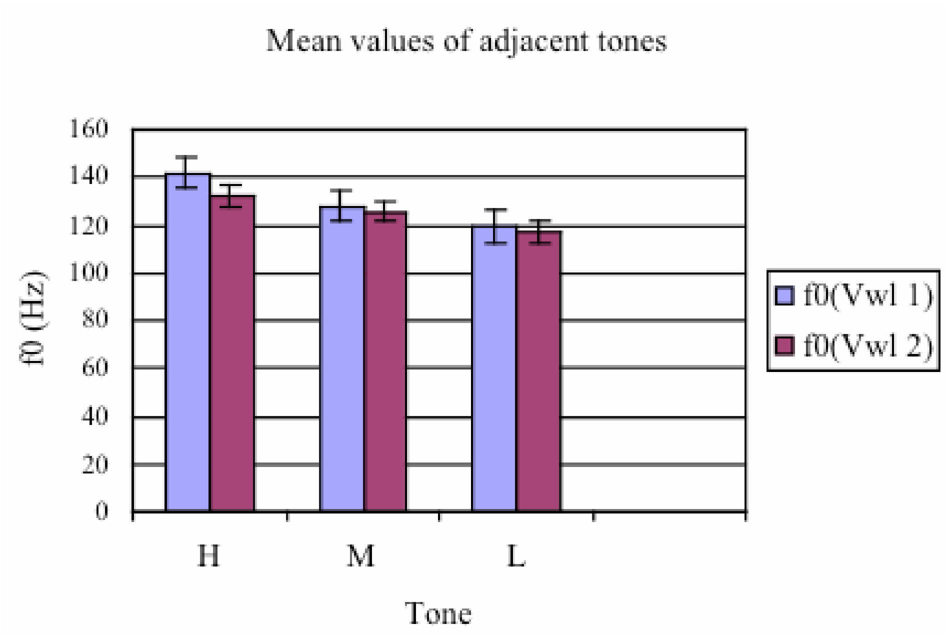
4.2 Results

The descriptive statistics for the f0 values of two adjacent H, M, and L tones within an IP is given below. The table also provides the mean and standard deviations for the differences in fundamental frequency between the adjacent tones (rows seven and eight) as well as for the rate at which the f0 value of the second vowel differs from that of the first (the last two rows). A bar graph summarizing the findings is presented below.

(19) a.

TONE	H	M	L
NUMBER OF PAIRED MEASUREMENTS	14	78	51
MEAN: f0(Vwl 1)	142	127.772	119.529
MEAN: f0(Vwl 2)	132.167	125.759	116.882
STD. DEV: f0(Vwl 1)	1.809	3.385	3.288
STD. DEV: f0(Vwl 2)	5.006	4.225	3.592
MEAN: f0(Vwl 2)-f0(Vwl 1)	-9.833	-2.013	-2.647
STD. DEV: f0(Vwl 2)-f0(Vwl 1)	4.196	3.119	3.411
MEAN: RATE OF CHANGE [f0(Vwl 2)-f0(Vwl 1) ÷ f0(Vwl 1)]	-0.069	-0.016	-0.022
STD. DEV: RATE OF CHANGE [f0(Vwl 2)-f0(Vwl 1) ÷ f0(Vwl 1)]	0.030	0.024	0.028

b.



4.3 Discussion

Contrary to claims made in the literature that pitch declination is a purely phonetic phenomenon without regard to the phonological identity of tone sequences (Pierrehumbert and Beckman (1988)), and in line with our initial observations, the rate of declination for adjacent underlying H tones is considerably greater than for M and L tones. On average, an H tone immediately following another H tone will be produced with a fundamental frequency 6.9% lower than the first. Adjacent mid and low tones, on the other hand, only show a declination rate of 1.6% and 2.2% respectively. In this respect, Nupe differs from the related language Yoruba, in which the rate of declination is greatest for L tones and most minimal for H tones (Laniran (1992)). Given these results, we'd expect greater discrepancies between the f0 values of H tone verbal elements in verb doubling constructions than for verbal elements in any other tonal category, especially when a healthy number of syllables separate the two verbal elements. This is precisely what we observe when comparing the data in (7) and (8) with the data in (14).[10] That is not to say that we don't expect the f0 values of M or L tone verbal elements to differ in verb doubling constructions. However, given the low rates of declination for these tonal categories, if we find that such elements do considerably vary, we would expect the predominant source of variation to lie elsewhere (for instance, within the domain of tonal coarticulation or perhaps some intonational phenomenon).

[10] Given that underlying M and L tones faithfully surface at the IP boundaries of verb doubling constructions, it is fair to compare the data in (7) and (8) with the data in (14).

The number of paired measurements for adjacent H tones in this experiment was significantly less than the number of paired measurements for the other tonal categories. This was not intentional, but rather a consequence of using the same data from Experiment 1. Although this may be partly responsible for the higher rate of declination in adjacent H tones when compared to the rates for the other categories, the low standard deviation values for these measurements suggest that in general the H tone data collected in this experiment is largely representative of adjacent H tones at various points along the utterance in the language. We conclude that although fewer observations of adjacent H tones were made than for the other tonal categories, the data in (19) still stands: adjacent H tones show a much greater rate of pitch declination than M or L tones in Nupe.

5 Experiment 3: categorical identity of tones in verb copy constructions

We turn now to the central focus of this study. In this section, we will compare the tonal properties of verbs with the tonal properties of their copies in a construction we have called "the verb doubling construction". We seek to determine whether the tonal categories of both elements can be considered phonologically identical despite the fact that phonetically, the f0 values of both elements are typically divergent. Drawing on the results from previous experiments, we will restrict our attention to contexts in which V2 surfaces in non IP-final positions and take pitch declination into account when determining the categorical identity of the verb and its copy.

5.1 Methods

As in the prior two experiments, the subject is the same male native speaker of Nupe. The methods of elicitation and recording employed in this experiment do not differ from the methods used in experiments one and two. Given the effects of IP boundaries in verb doubling constructions (cf. the results from experiment one), only sentences in which V2 surfaced IP-medially were considered. Initially, thirty-one verb-doubling sentences were recorded (with three token utterances per sentence), however, at the time of the recording, the effects of IP boundaries in verb copy constructions were not known/experimentally verified. As a consequence, only five of the thirty-one recorded sentences were suitable for analysis. Thus, the results of this experiment are based on fifteen recorded tokens of the following five syntactically complex sentences.

(20) a. Nàn`á **má** èwò **má** lu. (Modal-auxiliary construction)
Nana know garment know weave
‘Does Nana know how to weave garments?’
#‘Nana DOES know how to weave garments.’

b. Nàn`á **yá** èwò yin **yá** lu. (Modal-auxiliary construction)
Nana begin garment PRT begin weave
‘Did Nana begin to weave garments?’
#‘Nana DID begin to weave garments.’

c. Nàn`á **lá** lèm`ú **lá** ná. (Serial verb construction)
Nana take lime take wash
‘Did Nana take the lime and then wash it?’
‘Nana DID take the lime and then wash it.’

d. Nàn`á **li** lèm`ú **li** ná. (Serial verb construction)
Nana pick lime pick wash
‘Did Nana pick the lime and then wash it?’
‘Nana DID pick the lime and then wash it.’

e. Nàn`á **mà** lulu **mà** ná. (Serial verb construction)
Nana borrow cotton borrow wash
‘Did Nana borrow the cotton and then wash it?’
‘Nana DID borrow the cotton and then wash it.’

Nine of the fifteen utterances deal with pairs of verbs lexically specified as having H tones underlyingly. M and L tone verbs in the construction comprise the remaining six utterances. As in the other experiments, the peak f0 values for H tones were recorded and measurements for the f0 values of M and L tones were made in the middle of the vowel. Although the data set is small, the environments in which the verb and its copy surface are for the most part uniform across all utterances. V1 (which I will refer to as the “copy” verb) immediately follows the subject in all utterances; it is the third syllable in each recorded sentence; and it always follows a rising tone realized on the low vowel [*a*]. V2, on the other hand, is always the penultimate syllable in each sentence in (20), however its tonal environment is not constant across all utterances. The relationship between V1 and V2 is also largely consistent in this data set. With the exception of (20b), two syllables intervene between the verb and its copy. Due to the fact that the environments in which V1 and V2 are realized is predominantly constant in our data set, our results are reliable despite the limitations in total number of observations.

Given that we know that both tonal coarticulation and pitch declination play a role in the variation of f0 values within tonal categories, our strategy in comparing the tonal properties of V1 and V2 in this experiment will be to factor in the effects of pitch declination (which we observed to be somewhat substantial in certain cases (cf. (11a,b)) and ignore the effects of tonal coarticulation (which do not appear to be as prominent (cf. (5c)). If the fundamental frequency values of both verbs can be shown to be non-significantly different despite the fact that tonal coarticulation was not taken into consideration, we can infer that bringing the effects of the phenomenon into the fold will only increase the degree with which the f0 values of the two verbal elements are judged to be non-significantly different. Now, our calculated rate of pitch declination for each tonal category is valid only for sequences of two adjacent syllables. Because the utterances recorded in this experiment involve environments in which the verb and its copy are non-adjacent (separated by two to three syllables), we will need to invent a way of taking the effects of pitch declination into consideration when comparing the f0 values of the non-adjacent pair of verb and copy. Let's say we had calculated a more sophisticated rate of pitch declination over intervals of time that could be used to predict the f0 value of a syllable, say, four syllables away from a given target of tonal category T. How would we compare the tonal identity of a verb and its copy in such a case to determine whether the verbal elements both belong to category T? We would begin by observing the f0 value of the verbal element pronounced first (the copy) and on the basis of this figure compute the predicted value of a syllable of the same tonal category (affected by pitch declination) realized four syllables away. We'd then compare the actual f0 value of V2 to this number. If the two values can be shown to be non-significantly different, we'd have evidence that the discrepancy between the fundamental frequencies of V1 and V2 is mainly due to pitch declination and not to differences in tonal category. In this experiment, we will use a similar method to compare the f0 values of V1 and V2 while taking the effects of pitch declination into consideration. Our calculated rate of declination was based on adjacent syllables with identical tones. Because declination is exponential rather than linear (Shih (2000)), we can only compute the predicted value of a hypothetical syllable of like tone adjacent to V1. That is, we cannot generalize from our rates to predict the f0 value of anything more than one syllable away from the copy. We can therefore only compare the actual f0 realization of V2 to the predicted value of a hypothetical syllable adjacent to V1. Given that V2 will still be separated from this hypothetical target by one syllable (two, in the case of (20b)), we expect that the resulting values will be somewhat similar, but not precisely so. If, however, the two values can be shown to be non-significantly different despite the fact that not all influence of pitch declination had been factored in (or tonal coarticulation for that matter), we have good evidence that once again, variation in f0 values is an epiphenomenon and does not reflect the fact that V1 and V2 belong to distinct tonal categories. The statistical comparison of fundamental frequency values for hypothetical syllables computed on the basis of f0(V1) and the actual f0 values of V2 will be made by way of paired two sample t-tests.

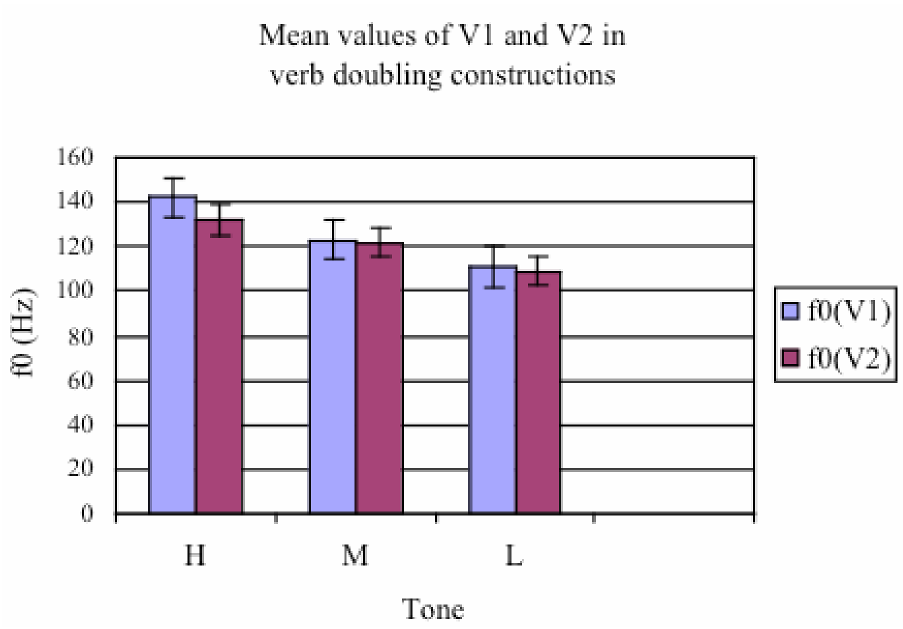
5.2 Results

The f0 values of V1 and V2 for all sentences in (20) are presented in the table below and in the graph that follows. The descriptive statistics for these measurements are also provided. (Fundamental frequency values for particular tonal categories are denoted by subscripts on V. Where no subscript appears, the value is taken to range over all tonal categories.)

(21) a.

SENTENCE	TOKEN	/TONE/ (V2)	f0(V1)	f0(V2)	f0(V2)-f0(V1)
18a	1	H	147	134	-13
18a	2	H	155	135	-20
18a	3	H	152	132	-20
18b	1	H	140	133	-7
18b	2	H	137	132	-5
18b	3	H	137	132	-5
18c	1	H	135	130	-5
18c	2	H	136	130	-6
18c	3	H	137	132	-5
18d	1	M	124	120	-4
18d	2	M	122	123	1
18d	3	M	124	122	-2
18e	1	L	111	110	-1
18e	2	L	111	109	-2
18e	3	L	112	108	-4

b.



Mean $f0(V1_H) = 141.778$	Std. Dev $f0(V1_H) = 7.563$
Mean $f0(V2_H) = 132.222$	Std. Dev $f0(V2_H) = 1.641$
Mean $f0(V1_M) = 123.333$	Std. Dev $f0(V1_M) = 1.155$
Mean $f0(V2_M) = 121.667$	Std. Dev $f0(V2_M) = 1.528$
Mean $f0(V1_L) = 111.333$	Std. Dev $f0(V1_L) = 0.577$
Mean $f0(V2_L) = 109.000$	Std. Dev $f0(V2_L) = 1.000$
Mean $f0(V2_H) - f0(V1_H) = -9.556$	Std. Dev $f0(V2_H) - f0(V1_H) = 6.444$
Mean $f0(V2_M) - f0(V1_M) = -1.667$	Std. Dev $f0(V2_M) - f0(V1_M) = 2.517$
Mean $f0(V2_L) - f0(V1_L) = -2.333$	Std. Dev $f0(V2_L) - f0(V1_L) = 1.528$
Mean $f0(V1) = 132.000$	Std. Dev $f0(V1) = 14.213$
Mean $f0(V2) = 125.467$	Std. Dev $f0(V2) = 9.620$
Mean $f0(V2) - f0(V1) = -6.533$	Std. Dev $f0(V2) - f0(V1) = 6.300$

The degree to which V1 and V2 differ in fundamental frequency across all tonal categories in verb doubling constructions parallels the differences in f0 values observed for adjacent like-tones in non-verb doubling sentences (visually compare (19b) with (21b)). We will exploit this parallel in arguing for the categorical identity of tones in doubling constructions shortly. The data clearly show that the average difference in fundamental frequency between the participating verbs in doubling constructions is greater for verbs of category H than for verbs in the other categories.[11] Given that on average, H tone-bearing verbal elements in these

[11] In particular, the considerable difference between f0(V1) and f0(V2) in (19a) is likely due to both tonal coarticulation and pitch declination equally. In this sentence, V2 is preceded by two consecutive L tones, which arguably drive down the fundamental frequency on the tone. In this case, ignoring the effects of tonal coarticulation is clearly an oversimplification. However, as we

constructions differ between nine to ten hertz, it is not surprising that directly comparing the f0 values of $V1_H$ to $V2_H$ yields the result that the two values are significantly different (i.e. that the tones on V1 and V2 do not belong to the same category). This is shown below.

(22) t-Test: paired two sample for means (comparing f0($V1_H$) to f0($V2_H$))

	f0($V1_H$)	**f0($V2_H$)**
MEAN	141.778	132.222
VARIANCE	57.194	2.694
OBSERVATIONS	9.000	9.000
PEARSON CORRELATION	0.740	-
HYPOTHESIZED MEAN DIFFERENCE	0.000	-
DEGREES OF FREEDOM	8.000	-
t STAT	4.448	-
P(T<=t) ONE-TAIL	0.001	-
t CRITICAL ONE-TAIL	1.860	-
P(T<=t) TWO-TAIL	0.002	-
t CRITICAL TWO-TAIL	2.306	-

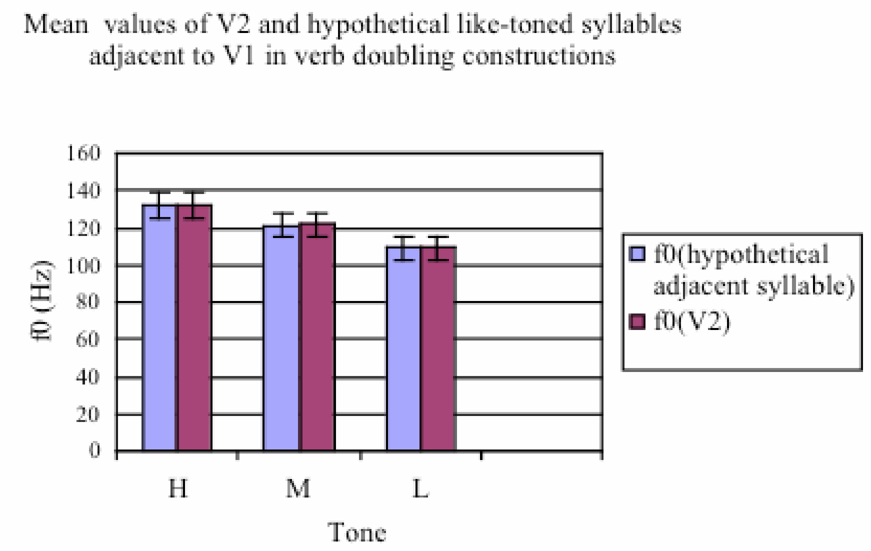
However, when we compute the value of a hypothetical like-toned syllable adjacent to V1 (on the basis of our previously determined rate of pitch declination) and compare the actual fundamental frequency of V2 to this figure, we obtain a different conclusion. (Recall that the rate of pitch declination determined in §4.2 was 6.9% for H tones, 1.6% for M tones, and 2.2% for L tones.) The following data show that the f0 values of V2 in our recorded utterances are roughly similar to the values of these hypothetical adjacent syllables. In certain cases, the actual fundamental frequency of V2 is slightly greater than the value of the hypothetical adjacent tone. This is reflected in the positive values of the final column below and can be attributed to the effects of tonal coarticulation. The data below along with the results of the subsequent t-test suggest that the considerable differences observed between the fundamental frequencies of the verb and its copy (and in particular, f0($V1_H$) and f0($V2_H$)), are in fact the result of pitch declination (and to a certain extent, tonal coarticulation) and thus do not reflect a difference in the tonal categories of the verb and its copy in the construction.

show in (22b), we can still get the result that the f0 realizations of V1 and V2 are non-significantly different when only pitch declination is factored in.

(23) a.

SENTENCE	TOKEN	/TONE/ (V2)	f0(V1)	f0(HYPOTHETICAL ADJACENT σ)	f0(V2)	f0(V2)-f0(HYPOTHETICAL ADJACENT σ)
18a	1	H	147	136.86	134	-2.86
18a	2	H	155	144.31	135	-9.31
18a	3	H	152	141.51	132	-9.51
18b	1	H	140	130.34	133	2.66
18b	2	H	137	127.55	132	4.45
18b	3	H	137	127.55	132	4.45
18c	1	H	135	125.69	130	4.31
18c	2	H	136	126.62	130	3.38
18c	3	H	137	127.55	132	4.45
18d	1	M	124	122.02	120	-2.02
18d	2	M	122	120.05	123	2.95
18d	3	M	124	122.02	122	-0.02
18e	1	L	111	108.56	110	1.44
18e	2	L	111	108.56	109	0.44
18e	3	L	112	109.54	108	-1.54

b.



Mean f0(Hypothetical Adjacent H) = 131.998
Mean f0(Hypothetical Adjacent M) = 121.363
Mean f0(Hypothetical Adjacent L) = 108.887
Mean f0(Hypothetical Adjacent σ) = 125.249
Mean f0($V2_H$) = 132.222
Mean f0($V2_M$) = 121.667
Mean f0($V2_L$) = 109.000
Mean f0(V2) = 125.467
Mean f0($V2_H$) - f0(Hypothetical Adjacent H) = 0.224
Mean f0($V2_M$) - f0(Hypothetical Adjacent M) = 0.303
Mean f0($V2_L$) - f0(Hypothetical Adjacent L) = 0.113
Mean f0(V2) - f0(Hypothetical Adjacent σ) = 0.218

Std. Dev f0(Hypothetical Adjacent H) = 7.040
Std. Dev f0(Hypothetical Adjacent M) = 1.137
Std. Dev f0(Hypothetical Adjacent L) = 0.566
Std. Dev f0(Hypothetical Adjacent σ) = 10.883
Std. Dev f0($V2_H$) = 1.641
Std. Dev f0($V2_M$) = 1.528
Std. Dev f0($V2_L$) = 1.000
Std. Dev f0(V2) = 9.620
Std. Dev f0($V2_H$) - f0(Hypothetical Adjacent H) = 5.930
Std. Dev f0($V2_M$) - f0(Hypothetical Adjacent M) = 2.50
Std. Dev f0($V2_L$) - f0(Hypothetical Adjacent L) = 1.517
Std. Dev f0(V2) - f0(Hypothetical Adjacent σ) = 4.617

c. t-Test: paired two sample (comparing f0(hyp adj σ) to f0(V2))

	f0(HYPOTHETICAL ADJACENT σ)	**f0(V2)**
MEAN	125.249	125.467
VARIANCE	118.438	92.552
OBSERVATIONS	15.000	15.000
PEARSON CORRELATION	0.906	-
HYPOTHESIZED MEAN DIFFERENCE	0	-
DEGREES OF FREEDOM	14.000	-
t STAT	-0.183	-
P(T<=t) ONE-TAIL	0.429	-
t CRITICAL ONE-TAIL	1.761	-
P(T<=t) TWO-TAIL	0.858	-
t CRITICAL TWO-TAIL	2.145	-

Unlike the case of the direct comparison of the f0 values of H-tone verbs and their copies, the considerably high p-value in this t-test (0.858) suggests that any variation with respect to f0(V2) and the fundamental frequency of the hypothetical adjacent syllable is most likely due to error. Of course, the results of this t-test are partially biased due to the fact that nine paired measurements were made for verbal elements of category H and only three such measurements were made for categories M and L. The following t-test compares only the f0 values of $V2_H$ with those of hypothetical H tones adjacent to $V1_H$. Again, the outcome suggests that H-toned copies are not significantly different from their doubles with respect to fundamental frequency once the effects of pitch declination are taken into account.

(24) t-Test: paired two sample (comparing f0(hyp adj σ_H) to f0($V2_H$))

	f0(HYPOTHETICAL ADJACENT σ_H)	**f0($V2_H$)**
MEAN	131.998	132.222
VARIANCE	49.565	2.694
OBSERVATIONS	9.000	9.000
PEARSON CORRELATION	0.740	-
HYPOTHESIZED MEAN DIFFERENCE	0.000	-
DEGREES OF FREEDOM	8.000	-
t STAT	-0.114	-
P(T<=t) ONE-TAIL	0.456	-
t CRITICAL ONE-TAIL	1.860	-
P(T<=t) TWO-TAIL	0.912	-
t CRITICAL TWO-TAIL	2.306	-

We conclude that once the effects of pitch declination are taken into consideration, the f0 values observed within tonal categories can be shown to be non-significantly different. In accordance, we do not reject the null hypothesis that CAT($Tone_{V1}$) = CAT($Tone_{V2}$).

5.3 Discussion

Assuming that the rate of pitch declination we determined for strings of two adjacent like-toned syllables is somewhat accurate, we find that although the actual f0 values of V2 differ from those of V1, they differ in rather predictable ways. Because of this finding, it is highly plausible to conclude that the tonal category of the copy verb is *phonologically* identical to the tonal category of the original verb. By phonologically identical, we mean that although the acoustic (phonetic) properties of the tones differ (fundamental frequency, amplitude/intensity, etc.), they behave as if they belong to the same phonological category (i.e. the degree to which f0(V2) differs from f0(V1) is largely dependent on the tonal category of V1). Independent support for this conclusion comes from the intuitions of native speakers who perceive the tones to be invariant across both instantiations of the verb. Given that tone is lexically contrastive in the language, if it were the case that the tones on V1 and V2 belonged to different categories, the semantics of the resulting sentence would noticeably change. For example, consider the following utterance.

(25) Musa gó koto **gó**.
Musa tie box **tie**
'Musa DID tie the box.'
'Did Musa tie the box?'

In order for this sentence to be ambiguous between an emphatic and Yes/No question construal, the speaker must classify V2 as bearing a H tone, despite the low value of its surface fundamental frequency. If however, the speaker determined the lexical status of V2 on the basis of its surface f0 realization alone, the sentence would no longer admit either an emphatic or Yes/No question interpretation. Rather, the sentence would come to have the semantics of a "consequential" type serial verb construction, not to mention the syntax of one as well (Stewart (2001)).

(26) Musa gó koto **gò**.
Musa tie box **brace**
'Musa tied the box (and then) braced it.'
as: 'Musa DID tie the box'/'Did Musa tie the box?'

This suggests that the semantic computation of such sentences (and by analogy, all sentences in general) is performed independently of the PF output as in Chomsky 1981, 1995. Moreover, as previously mentioned, this intuition is also reflected in the orthography whenever verb doubling constructions appear in print (Ahmadu Kawu, personal communication). Our experimental results and the judgments of native speakers thus converge in this respect.

In the final section of this paper, we summarize the results of our investigation and discuss the theoretical implications of the finding that the tonal categories of the verb and its double are phonologically identical.

6 The big picture – summary and implications of the study's major findings

On the basis of the recorded speech of one native speaker of Nupe, we have found evidence that with respect to verb doubling constructions, the tone of a verb and the tone of its copy belong to the same phonological tone category. Although this finding mirrors the intuitions of native speakers and finds support in the orthographical representation of verb copy sentences in the language, it is somewhat surprising given the fact that in certain cases the fundamental frequency of the first verb in the construction can differ from the fundamental frequency of the second verb by as much as twenty hertz (cf. (21)). When we look at the speaker's tone range data, we find that twenty hertz is roughly the range within which fundamental frequencies vary within tonal categories in non-verb doubling constructions. This data is presented below.

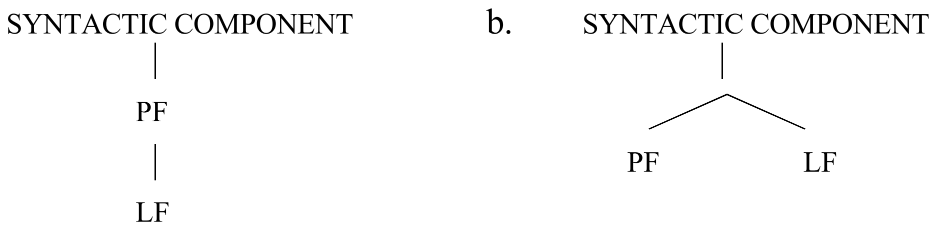
(27) Summary of tone values and ranges in non-verb doubling contexts

TONE	COUNT	MEAN	STD. DEV	RANGE
H	36	142.19	9.02	125-156
M	185	127.07	4.03	117-138
L	148	117.82	3.88	108-126

With regard to the data in (21), the range of f0 values for underlying H-tone bearing second verbs in Nupe verb copy constructions is 130-135 Hz. Note that these values fall within the range of *both* H and M tones for this speaker. Similarly, the range of values for underlying M-tone bearing second verbs in the construction is 120-123 Hz. Again, these values fall within the range of two tonal categories: M and L. Nonetheless, speakers do not perceive a categorical difference between the tones on the verb and its copy. We accounted for the significant intra-categorical variation in fundamental frequency in verb doubling constructions by appealing to the phenomena of pitch declination and tonal coarticulation. Although we were only able to determine the degree to which like-toned adjacent syllables vary in their f0 values (independent of time), we were able to apply this finding to the case of verb doubling constructions to determine that the differences in fundamental frequency between V1 and V2 were mainly due to pitch declination and secondarily to tonal coarticulation. Once this was factored in, we were able to demonstrate that the differences between the fundamental frequencies of both verbs in the construction were not significant enough to warrant distinguishing the two on the basis of tonal category. We concluded that although phonetically distinct, both participating verbs could be said to belong to the same phonological tone category.

This conclusion is met with an interesting theoretical implication as well. Recall the discussion in the introduction in which we considered two plausible ways to analyze the syntax of verb doubling constructions. One approach was that each verbal element was base-generated in distinct syntactic positions; this was the quasi-serial verb construction proposal. The other alternative was that given the fact that verbs can be independently shown to raise in the language (Kandybowicz and Baker (2003)), verb doubling constructions can simply be analysed as cases of verb movement in which the verb is copied into some higher syntactic position and the trace of movement is spelled-out phonetically rather than being deleted (in line with Chomsky's (1995) copy theory of movement). The results of our study lend support to the latter theory of verb doubling constructions. If these sentences are true copy constructions, we'd expect both verbal instantiations to share certain syntactic, semantic, and morpho-phonological properties, among them tonal specification. In the case of Nupe verb doubling constructions, as we have seen, it is clear that the participating verbs share *all* such properties. The former theory of verb doubling constructions (the quasi-serial verb construction type approach) neither makes the prediction that both verbal elements will systematically share these properties nor can account for this fact. Our phonological/tonological results thus inform syntactic analysis to a degree. We also saw briefly in section 5.3 that the semantic interpretation of verb doubling constructions sheds light on the syntax-semantics-PF interface. Given the fact that the interpretation of V2 is semantically identical to that of V1 despite the fact that the phonetic properties of the tones on each occurrence are non-identical as well as the fact that tone is lexically contrastive in the language, the PF output of such constructions cannot serve as the input to the semantic component (LF) as in (28a). Evidence for this comes from the fact that verb-doubling constructions do not show the semantics of certain types of serial verb constructions (cf. (26)). This suggests the independence of the PF and LF components (schematically, as shown in (28b below), as in all post-GB theories of the architecture of grammar.

(28) a.



The results of our investigation are thus non-trivial, as they bear on other aspects of Nupe grammar as well as linguistic theory in general.

There is much room for future research. The findings of this study need to be tested on additional Nupe speakers and generalized accordingly. More data needs to be collected for certain measurements and tone categories (H tones, in particular). A more precise characterization of pitch declination is desirable and the precise impact of tonal coarticulation needs to be worked out. Nonetheless, the results of this study are informative and bear on other aspects of the language. As mentioned in the introduction, this paper represents the first step toward a quantitative study of Nupe tonology. It is hoped that it is also not the last.

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