A PHONETIC ANALYSIS OF IBIBIO TONES: A PRELIMINARY INVESTIGATION

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This study is an ongoing investigation into the phonetic nature of tone in Ibibio, a Lower Cross language of the (New) Benue-Congo family. The object of the study is to characterize the nature of Ibibio tones, find out the nature of donwtrend phenomena including downdrift and downstep, and provide an F_0 scaling function that would allow to predict F_0 values for Ibibio tones. The experimental design is adapted from that used in Liberman et al. (1993) on tonetic research on Igbo, another (New) Benue-Congo language.

The preliminary results show that there are three distinct tones in Ibibio, i.e., high (H), low (L), and downstep high (!H), and that there is a phonetic difference between a downstep high tone that is phonologically realized and downdrift which is a phonetic realization. There appears to be downtrend effects on tone sequences but given the limited data at our disposal, it is difficult to arrive at a firm conclusion until more data is collected.

Cette enquête en cours étudie la nature phonétique du ton en ibibio, une langue 'Lower Cross' de la (Nouvelle) famille Bénoué-Congo. L'objet de l'étude est de caractériser la nature des tons en ibibio, de découvrir la nature des tons à tendance descendante ('downtrend') y compris ceux qui baissent progressivement dans une unité syntaxique ('downdrift'), et ceux qui baissent automatiquement sans l'intervention d'un ton bas ('downstep'), et de fournir un moyen qui nous permettra de mesurer et de prédire les valeurs F_0 pour les tons en ibibio. Le modèle expérimental est adapté de celui employé par Liberman et al. (1993) vis-à-vis de la recherche sur le ton en igbo, une autre langue de la (Nouvelle) famille Bénoué-Congo.

Les résultats préliminaires révèlent qu'il y a trois niveaux de tons en ibibio, c'est-à-dire, haut (H), bas (L), et haut abaissé (!H) ('downstep high'). Il y a aussi une différence phonétique entre le ton haut abaissé qui est réalisé phonologiquement et le ton d'abaissement progressif ('downdrift') qui est une réalisation phonétique. Il nous semble qu'il existe des effets d'abaissement ('downtrend effects') sur les séquences de tons, mais avec les données limitées dont nous disposons, il est difficile d'arriver à une confirmation définitive sans autres données envisagées.

0. INTRODUCTION[1]

Tone is an important element in African and Asian languages, and it is a well known fact that tone in African languages is used to make lexical and grammatical distinctions. There is therefore an urgent need for the phenomenon of tone to be properly understood in order that better analyses of the vast majority of African languages which are tonal can be effectively carried out.

Ibibio belongs to the Lower-Cross language group of the Benue-Congo branch of the Niger-Congo language family (Williamson 1989) and is spoken in Akwa Ibom State in the South-Eastern part of Nigeria. Like most Benue-Congo languages, Ibibio is tonal and is a classic example of a terraced-level tone language (Welmers 1973). This study is an ongoing investigation into the phonetics of Ibibio tone.[2] Ibibio has attracted a fair amount of attention in the areas of syntax and phonology. Although important work has been done on the grammatical aspect of Ibibio tone (Kaufman 1968), the phonetics and phonology of Ibibio tones have not received equivalent attention. This work is an attempt to fill the experimental gap in this regard, and it is hoped that this will provide a phonetic description of the tones, with particular attention to the interaction between identical and different tonal sequences, thereby providing a clearer picture of the downtrend phenomena including downdrift and downstep. Moreover, following recent work by Liberman et al. (1993) on Igbo and Bird (1994) on Dschang (Bamileke), in addition we ultimately hope to provide an F_0 scaling function which will

[1] We are grateful for comments from Akin Akinlabi, Steven Bird, Unyierie Idem, Bruce Connell, Robert Hedinger, the audiences both at the University of Edinburgh Department of Linguistics Conference 1994 and the Colloquium of African Languages and Linguistics (CALL), Leiden 1994, and an anonymous JWAL reviewer of this article.

[2] Ibibio has attracted a fair amount of attention mainly in the areas of syntax (Kaufman 1968, Essien 1985, 1986, 1990, Inim 1987, etc.), phonology (Boys 1978, Umoh 1985, Urua 1987, 1990, Imoh 1988, Utip 1990), and on experimental work on the consonants (Garnes 1975, Connell 1987, 1991). This is, of course not ignoring the pioneering and important work done on Ibibio by Jeffreys (1935) and Simmons (1957).

allow us to predict F_0 values for Ibibio tones. Although the general goal of this article is to provide a phonetic description of Ibibio tone, we also hope to discover whether there is any relationship between HL and H!H sequences and the nature of that relationship; and to establish the relationship between phonetic implementation rules and phonological realisations.

In §2 we present the phonological realization of Ibibio tones. Section 3 gives the experimental design. In §4, the results and discussion of the experiments are presented. These show that there are three distinct tones in Ibibio, viz., H, L and !H. Initial H's show a rising contour and effect a slight lowering of subsequent H's. However, in a sequence of H's the final H is raised and is therefore higher than the immediately preceding H tone. Low tones, on the other hand, are fairly stable initially and medially but in a final position they exhibit a fall. It does appear that L tone sequences also exhibit downtrend effects. Alternation of H's and L's and H's and !H's also appear to exhibit some lowering indicating that both H's and L's become lowered. However, in a sequence of H's and !H's, the final H may not be raised higher than the immediately preceding H tone, and not even as high as that H. We hope to carry out further research in this area with more participants representing gender and dialect distinctions in the near future.

1. IBIBIO TONES

Three contrastive tones arise in phonological analysis in Ibibio H, L, and !H (Urua 1994). The !H tone, however, has a restricted distribution and may only occur after a preceding H tone. Other tonal realisations include a high-low (HL) falling and a low-high (LH) rising contour tones. Each syllable is tone bearing with either a level tone or one of the contour tones. With this, a disyllabic word in Ibibio may have any one of the following patterns, H-H, H-L, H-!H, L-L, and L-H (barring word class restrictions) as in (1a). Verbs, for instance, may not be longer than two syllables with the final tone on the second syllable being predictably H as in (1).[3]

(1)	H		L		L-H	
	di	come	**kpɔ**	carry child on back	**kaa**	go
	ma	like/love	**kɔ**	gather	**naa**	lie down
	dep	buy	**dep**	fall (as in rain)	**fre**	forget
	sana	be clean	**bɔ**	receive	**saŋa**	walk
	dɔkkɔ	tell	**bon**	father a child	**yommo**	boo at
	faaŋa	argue	**bɔɔk**	nurture	**bɔɔrɔ**	respond
a.	H-H		H-L ~ H-HL		H!H	
	ukot	leg	**ikat**	basket	**uke**	where
	eba	breast	**ebek**	chin	**mbɔk**	please
	etap	saliva	**ufɔk**	house	**inuen**	bird
	ikpa	cane	**eyop**	palm fruit	**ɔbɔɔŋ**	king
	abaŋ	pot	**unam**	meat animal	**ekraŋ**	type of bird
b.	L-L		L-H			
	ekpat	bag	**iwa**	cassava		
	usan	plate	**uko**	valour		
	enɔ	gift	**ata**	sixty		
	eka	mother	**uto**	poetry		
	akam	prayer	**ime**	patience		

Tonal sandhi occurs in Ibibio between the different tones. A HL contour tone following a H is usually in free variation with a L. The implication is that a L is

[3] The representation used in this study is a phonetic one unless otherwise stated.

realized as a fall after a H while a H may be realized as a lowered H after a L as in (2a) and (2b), respectively.

(2) a. **ufɔk** → **ufɔk**
H L H HL

b. **aako** → **ako**
LH H H !H

(2b) shows that there is downstep (non automatic lowering). Whether there is any phonetic difference between downstep (non automatic lowering), and downdrift (automatic lowering), and whether both H's and L's get lowered is part of the motivation for this investigation.

The HL and LH contour tones may also be assigned to single syllables as in the final syllables of the items in (3).

(3)

HL		LH	
àŋwâ	cat	**frǒ**	jump
òdû	whisper	**kàá**	go
édêt	tooth	**brě**	play (verb)
úkôt	in-law	**nàá**	lie down

2. THE EXPERIMENTAL METHOD

Two experiments were carried out for the purpose of this study.

2.1 EXPERIMENT I

In this experimental design, a speaker varies the pitch of voice to three different volumes, viz., loud, medium, and soft. There is a relationship between loudness and pitch because the louder a sound the higher the pitch range and conversely, the softer a sound the lower the pitch range. These different volumes were therefore used to ascertain whether the distinction between a HH and LL tone sequence would still be maintained when a HH tone pattern is said at a low pitch and when a LL pattern is said at a high pitch. Fifteen disyllabic items were used with three of these representing each of the following tone categories: H-H, H-L, H!H, L-L, L-H as in (4).

(4)

H-H	**ɔbɔŋ**	mosquito	**ukɔ**	burden	**ata**	type of insect
H-L[4]	**ɔbɔŋ**	cane	**ukot**	in-law	**ata**	specialist
H!H	**ɔbɔɔŋ**	king	**uko**	there	**ata**	he has chewed
L-H	**ubɔɔŋ**	pumpkin	**uko**	valour	**ata**	sixty
L-L	**ɔbɔn**	type of masquerade	**uku**	charisma	**ataat**	wasp

These items were written out on cards with glosses provided in English as well as information as to what volume each item was to be produced, i.e., loud, medium, and soft. To avoid a repetition effect, the cards were randomized to vary the sequencing of the tones and volume of production. The subject, a female Ibibio speaker aged 30 years and also a speaker of the Anaaŋ variety, was then asked to produce each item five times with the appropriate volume, making a total of 225 tokens. The experiment was recorded in the Edinburgh University Linguistics Department Phonetics Laboratory and pitch extraction was done using the ESPS Waves Program.

[4] Attention must be drawn to the fact that these forms frequently occur with a H-HL pattern in some Ibibio dialects. See §3.1.4.

2.2 EXPERIMENT II

The second experiment consisted of a recording of thirty-four utterances of longer tonal sequences of H's, L's plus a mixed set of H's, L's, and !H's instead of just disyllabic items. The subject for this experiment was a 37-year old female Ibibio speaker. Two recordings were done but only one set was used for the actual analysis. Some of the sample utterances are given in (5) according to tonal grouping. In this experiment only the normal conversational pitch was used, leaving out the loud and soft pitches used in Experiment I.

(5) H-H

i) **úkárákpá ké sé**	It is a sea monster s/he is looking at.
ii) **ŋ̀kánìká ké ŋ̀kánìká ké ŋ̀kánìká**	hour by hour

L-L

I) **ùtàsì yè àbàsì**	spicy vegetable and god
ii) **ǹtùʀùbè yè ùtàsì**	fog and spicy vegetable

H-L

i) **sé ètέ yè átà**	Look at the man and the specialist.
ii) **úfɔ̀k ékò ké à tɔ́ ètídòt ó dò**	It is the back of the house that you have planted that bitter leaf.

H!H

i) **á !fɔ́b á!tá á !fɔ́b á!ta**	S/he roasted and ate, roasted and ate.

L-H-!H

i) **ú!ké yè ú!kó**	where and there
ii) **ùkó yè á!kó yè ɔ́!bɔ́ɔŋ ké ú!kó**	PN and PN and king are over there.

2.3 F_0 MEASUREMENT

In measuring the F_0 values, three points per syllable were considered. These points depended on the particular tone in question, an indication of the difficulty in deciding which point to consider when trying to measure F_0 values of tones. One of the points was taken a little after the beginning of the first syllable to minimize the consonant perturbations of F_0; another was the peak for H and !H tones while yet another was a point towards the end of the syllable. There was a thorny problem of where to take the measurement for a non initial L tone and a L in a H-L and H-HL sequence because of the fall exhibited by the L tone in these positions even without a preceding H tone. The mid point value for the final L tone was eventually decided on for the following reason. Taking the lowest value would have had a considerable impact on the result obtained and would most likely have given a distorted result because of the sharp fall which characterizes non-initial L's as opposed to an initial L tone.

3. RESULTS AND DISCUSSION

The preliminary results obtained reveal variations in the phonetic features of the different tones. There is some indication to show that there is some kind of relationship between the different volumes of production, particularly the loud[5] in relation to the different tones. Apart from bringing about an increment in the amplitude, it seems that a loud volume also affects the contours of the tones. A soft volume on the other hand has a minimal effect by very insignificantly lowering the F_0 contours.

[5] Three volumes of production were used in this study, viz., loud, medium, and soft, corresponding approximately to the pitches used in speaking to someone in the next room, to someone within the same room and to someone beside the speaker, respectively. The medium pitch is therefore regarded as the normal conversational pitch.

3.1 EXPERIMENT I

Like Tone Sequences (H-H, L-L)

H-H sequence. The F_0 contour indicates that there is a rise for the initial H with mean F_0 values of 230Hz and 427Hz taken at the beginning and peak respectively. The second H, on the other hand, has the mean values 260Hz and 472Hz also at the beginning and peak points respectively, showing that the second H begins at a slightly higher pitch than the initial H.

No fall was observed for the H-H sequence but the second H appeared to maintain a steady pitch.

L-L sequence. An L-L sequence has a different F_0 contour from the H-H sequence. The initial L has a steady pitch while the second one has a falling contour and seems to begin at a slightly higher pitch than the initial L, an observation which is different from that reported by Liberman et al. (1993) for Igbo, where the second L is reported to begin at a lower pitch than the initial L. The mean F_0 values (of all three volumes) for the initial L and the second L are 236Hz and 233Hz, respectively. Notice that even though we have reported that the second L begins at a slightly higher pitch than the initial L, the overall mean value for the second L is slightly lower than that of the first L, and this is explained by the fact of the considerable downglide of the second L tone, with the result that the higher pitch and the downglide almost balance out the difference with the initial L. This underscores the problem of locating at what point in a syllable the F_0 values ought to be taken for a specific phonological tone.

Mixed Tone Sequences (H!H, H-L ~ H-HL, L-H)

H!H sequence. In Ibibio !H tones occur only following a H. A H!H sequence shows a gradual rise of the initial high similar to that of the initial high of a H-H sequence while the !H is realized at a lower level with a steady pitch. In fact, when the H!H sequence is produced at a low volume both the H and !H exhibit steady pitches with the !H still realized at a lower pitch than the initial H. The overall mean values for the H and !H are 283Hz and 248Hz, respectively, showing that the !H tone is considerably lower than the preceding H tone but also higher than the overall mean values for the L-L sequence. This excludes the possibility of the !H tone being regarded as a L tone.

H-L ~ H-HL sequence. The patterns H-L and H-HL occur in free variation with each other depending on which dialect of Ibibio is spoken. Ibibio as spoken in the Uyo, Uruan, Ibiɔnɔ and Itu areas exhibit a H-HL (falling contour) pattern while that spoken in Iman, Eket and Nsit areas have the H-L (level) variant. Although there was no H-HL sequence in the tonal patterns under investigation, this showed up in Experiment I nonetheless. This is as a result of tonal sandhi which is quite common in the language. In (1a), it was showed that H-L and H-HL occurred in free variation. This observation seems to have been borne out by this investigation. The subject was given a list of items that had a H-L tonal pattern but in the course of their production, sometimes she produced them with a H-L pattern and at other times with a H-HL. This created a split in the frequency for the H-L in the first experiment. However, the mean F_0 values for the H-L sequence are 292Hz and 251Hz, respectively while that of the H-HL sequence are 282Hz and 260Hz. Both the H-L and H-HL sequences portray a similar F_0 contour; the H-L has a rising H and a falling L, with the fall beginning at about the same level as the end of the preceding H tone. However, the beginning of the fall for the HL in a H-HL sequence starts at a point slightly higher than the end of the preceding H tone, and this suggests H spreading on to the L and a L raising. This accounts for the slight

L-H. The L-H sequence exhibits steady contours for both tones. The L is expectedly realized at a much lower pitch than the H with overall mean F_0 values of 227Hz and 287Hz for the L and H tones, respectively. When the L-H sequence was uttered at a loud volume, there was a rise in the initial L tone which was not present at medium and soft volumes. In fact, if anything, the initial L tended to show a slight lowering when said at a soft volume. On the whole, initial H's tend to have a rise while non-initial H's have a stable pitch; initial L's have a relatively steady pitch while non-initial L's have a falling pitch contour. When a loud volume is superimposed on an initial L tone, there is a rise in the L tone contour. Conversely, the superimposition of a soft volume on both initial H's and L's shows a rather insignificant fall in the pitch contour. There seems to be some kind of interrelationship between amplitude and a rise/fall, i.e., when the production is at a loud volume, there is an accompanying rise whereas a slight fall, almost imperceptible, accompanies a soft volume. This interface needs to be explored in more detail.

3.2 EXPERIMENT II

3.2.1 Overall Results

The values reported in this section are values for one set of recordings done at normal conversational pitch. F_0 values for the H and !H tones were taken at the vowel peak while the L tone values were taken at the vowel midpoint. In (6)–(10), a sample of the data used is presented.

(6) H-H

Text	**u**	**ka**	**ra**	**kpa**	**ke**	**se**
Tones	H	H	H	H	H	H
F_0	271	274	272	265	262	274

(7) L-L

Text	**u**	**ta**	**si**	**ye**	**a**	**ba**	**si**
Tones	L	L	L	L	L	L	L
F_0	213	204	211	205	193	183	180

(8) H!H

Text	**a**	**fɔ**	**ba**	**ta**	**a**	**fɔ**	**ba**	**ta**
Tones	H	!H	H	!H	H	!H	H	!H
F_0	293	283	288	267	278	265	279	267

(9) H-L

Text	**se**	**e**	**te**	**ye**	**a**	**ta**
Tones	H	L	H	L	H	L
F_0	289	231	245	202	227	180

(10) L-H

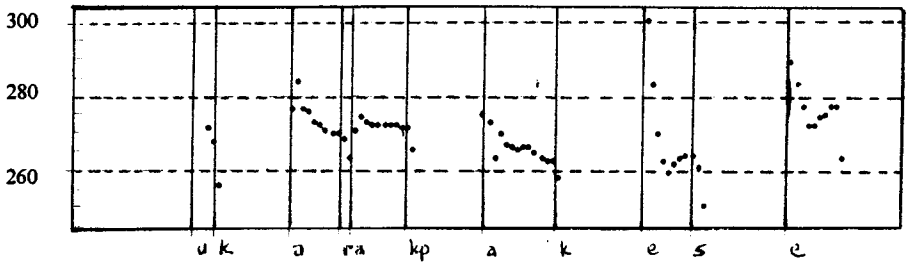
Text	**a**	**kɔ**	**ti**	**ke**	**a**	**ta**
Tones	L	H	L	H	L	H
F_0	210	311	204	247	193	218

3.2.2 H-H

In the second experiment with longer sequences of H tones, it seems that the H tone target is reached in the second syllable if the first syllable is a prefix and the first if the first syllable is stem initial. This seems to explain why the F_0 value for the second H tone was higher than the first in Experiment I. There appears to be some downtrend effects, i.e., a lowering of subsequent H's after the F_0 target has been reached as in (6), even without the intervention of any intervening L's. This seems to be different

from the results obtained by Connell and Ladd (1990) for Yoruba which shows that there is little or no declination for the H-H sequence. There is still a rise[6] of the initial H tone irrespective of the following tone, supporting the observation of Liberman et al. (1993) for Igbo that an initial H has a rising contour irrespective of the following tone, although this is not too clear for Ibibio given the limited data at our disposal. Moreover, final H tones in a H sequence are raised and are therefore higher than the immediately preceding H, which may suggest a phrase final raising as in (6) and (11).

(11)



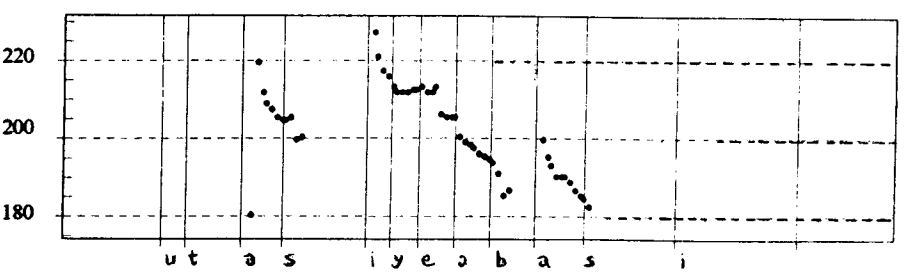
3.2.3 L-L

(12)L-L

Text	**u**	**ta**	**si**	**ye**	**a**	**ba**	**si**
Tones	L	L	L	L	L	L	L
F_0	213	204	211	205	193	183	180

Low tone sequences also exhibit very slight and insignificant downtrend effects as in (12) and (13) if this is considered syllable by syllable, but significant if the entire utterance is taken into consideration. The raise in F_0 at /ye/ may be due to consonant perturbation effects of the glide. But generally, it does seem that subsequent L's become somewhat lower without the intervention of a different tone. Moreover, the low tone target seems to be at the beginning of the second syllable if the first syllable is a vowel or nasal prefix, and this appears to explain why the F_0 value for the second syllable in the first experiment was higher than that of the first syllable.

(13)



[6] The first value reported is that on a noun prefix which has usually been found to be lower than the value at stem initial position. This statement therefore does not consider the value of 271 Hertz but begins from 274 Hertz.

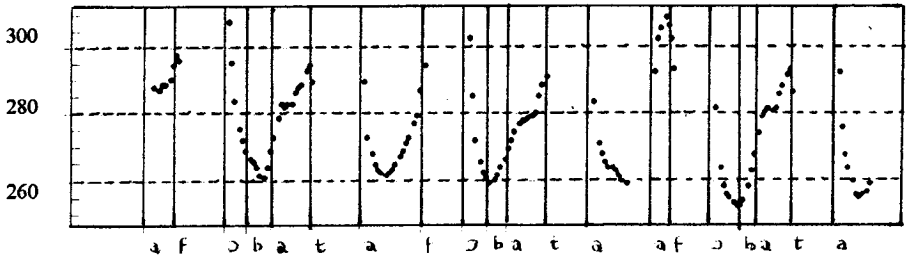
3.2.4 H!H

(14)H!H

Text	**a**	**fɔ**	**ba**	**ta**	**a**	**fɔ**	**ba**	**ta**
Tones	H	!H	H	!H	H	!H	H	!H
F_0	293	283	288	267	278	265	279	267

In longer sequences of H!H, it appears that the !H tones are fairly stable but where there is an intervention of L's in the sequence, !H's were also found to be slightly lowered. Crucially, the !H tones are distinct from both H and L tones as their F_0 values even in longer utterances were significantly lower than the H's and higher than those of the L's. There is therefore a distinction for H's, L's, and !H's as in (15).

(15)



3.2.5 H-L ~ H-HL

(16)H-L

Text	**se**	**e**	**te**	**ye**	**a**	**ta**
Tones	H	L	H	L	H	L
F_0	289	231	245	202	227	180

Longer sequences of HL pattern showed that after the initial H, subsequent H's are lower with the intervention of L's. But interestingly, after the L following the initial H, subsequent L's become lowered with a final L falling. In a HL sequence, therefore, both H's and L's exhibit downtrend effects.

3.2.6 L-H

(17)L-H

Text	**a**	**kɔ**	**ti**	**ke**	**a**	**ta**
Tones	L	H	L	H	L	H
F_0	210	311	204	247	193	218

An overall downtrend effect was also observed for sequences of LH tones. Apart from the initial L which tended to be higher on prefixes (indicating that the L tone target may be stem initial just as for the H tone), subsequent L tones after the target become lowered with intervening H's and subsequent H's are also lowered after the first H. However, unlike H tone sequences, the final H tone in a LH sequence is never raised higher than the level of the immediately preceding H tone or even to the same level for that matter.

3.3 DISCUSSION

From the results of both experiments, some general observations may be made. Firstly, there are cases of tonal sandhi where a L is raised when following a H. Secondly, downtrend effects appear to be exhibited by both sequences of H and L in Ibibio. And crucially, there is a phonetic difference between automatic lowering (downdrift) and non automatic lowering (downstep) as shown in Liberman et al. (1993) for Igbo and Dolphyne (1994) for Akan. It should, however, be pointed out that the results presented here are tentative, being based on only two female speakers of Ibibio.

Tonal sandhi (low raising). Yoruba, a (New) Benue-Congo tone language has been reported to raise a H before a L (Connell and Ladd 1990; Laniran 1992). Work reported by Liberman et al. (1993) for Igbo does not support such a raising. For Ibibio, our results seem to agree with Liberman's position because initial H's have a rising contour till the H tone target is reached irrespective of the following tone, which for Ibibio may be a H, L, or !H. The Ibibio result shows that in a H-L sequence, the L pitch contour continues from the H portion to a sharp fall. In a H-HL sequence, there is an actual spreading of the H on to the L which is manifested at the beginning of the HL contour as a higher pitch than the end of the preceding initial H. It seems that for Ibibio, it is not the H that is raised before a L but a L that is raised after a H, indicating a progressive tonal assimilation, implying that the H spreads to the following L causing it to be raised just like the progressive one described for Yoruba, except that in this case the L is raised after the H. This is not contradictory to the findings of Connell and Ladd (1990) and Laniran (1992), but a different interpretation of the findings. This is hardly surprising since different languages have different phonetic implementation rules as documented in the literature on tone languages. Moreover, it has to be remembered that whether H-L or H-HL is realized is largely dialect dependent. More importantly, it points to how phonology can be explained by looking at phonetics.

Downstep/downdrift. Tone languages, particularly those from West Africa, have been known to exhibit downdrift and downstep phenomena (Dschang, Igbo, Ibibio, Efik, Hausa, Akan, etc.). This has led to the distinction between automatic and non automatic downstep, where an automatic downstep is the lowering of non initial H's after intervening L's and non automatic downstep is the lowering of such H's without the benefit of intervening L's. Winston (1960), in a very perceptive article, accounted for downstep as a result of a lost or floating L tone. For more than three decades of tonetic/tonological research, this theory has been used to account for the non automatic lowering of a non initial and subsequent H tones since there are attested cases where this can be synchronically established in tone languages. However, in more recent studies on tone (Connell and Ladd 1990, Liberman et al. 1993, Dolphyne 1994, etc.), it now seems that this explanation for non automatic lowering is being challenged or is in need of some modification. It has been shown in instrumental studies on tone that there is a significant difference between a H!H and a HLH sequence. The degree of drop from a H to a !H in a H!H sequence and that of a drop from a H to the next H in a HLH sequence is much greater in the HLH sequence than in the H!H sequence. This seems to be borne out by this study given the apparent significant difference between H-L, L-H, and H!H sequences which have been presented in the previous section as well as with the results of the F_0 values in the longer utterances. If this is so, then there must be an explanation as to why a H after a !H can never be as high as the initial H. With the evidence at our disposal, there is a clear distinction between L, H, and !H tones. With more data, we intend to take a closer look at this aspect.

4. F_0 SCALING

Previous works by Liberman et al. (1993) and Bird (1994) have attempted to provide F_0 scaling functions which produce a sequence of F_0 values (in Hertz) from a tone sequence. The method is based on earlier work by Liberman and Pierrehumbert (1984) on intonational variances under changes in pitch range and length. Both studies involve data from tone languages (Igbo and Dschang), where speakers were required to produce utterances at a range of volumes (and hence pitch levels). After pitch extraction, an F_0 value was obtained for each tone bearing unit, and a regression analysis was performed on pairs of adjacent F_0 values. Following this method, the following regression equations were obtained for the tone sequences that occur in Ibibio, using the maximum values for H and !H tones and the minimum values for non initial L tones. Where L tones appeared finally, the F_0 value at the vowel midpoint was used, due to final low tone lowering. Standard error values for the gradient and intercept are reported in parentheses.

HH	$y = 1.15x - 24$	(SE: 0.09, 9)
H!H	$y = 0.83x + 12$	(SE: 0.09, 10)
HL	$y = 0.60x + 44$	(SE: 0.04, 8)
LH	$y = 1.13x + 30$	(SE: 0.11, 12)
LL	$y = 0.96x + 7$	(SE: 0.56, 7)

A number of observations can be made about these figures:

Non automatic downstep vs. automatic downstep. By composing the HL and LH functions above, we can predict the net drop in Fo between the two high tones in an HLH sequence. The equation is $y = 0.68x + 80$ (SE: 0.11, 25). This is significantly different from the equation for H!H, so we can conclude that a distinction must be drawn between these two kinds of downstep.

Repeated like tones. Observe that the equation for LL is not significantly different from $y = x$. Moreover, recordings of longer sequences of low tones showed no significant overall downtrend. Strikingly, however, we can observe an uptrend for HH sequences, particularly in the higher part of the subject's pitch range. Longer sequences of high tones we inspected did not show this rising behaviour, except at the periphery, and we had insufficient data to determine whether this was raising of the final high tone in a group (cf. Laniran 1992) or a lowering of the initial high tone in a group.

Asymptotic behaviour. The model predicts that sequences like H!H...!H...!H manifest asymptotic behaviour. If we repeatedly compose the equations for the H!H or for HLH with themselves, the result tends towards an asymptote. Some of our longer utterances likewise manifest this behaviour.

At present, we have insufficient data to be able to construct an explicit F_0 interpretation model along the lines of Liberman et al. (1993) and Bird (1994). However, this is one of our goals in subsequent work.

5. CONCLUSION

This study has attempted to characterize the phonetic nature of Ibibio tones showing that the tones high (H), low (L), and downstep high (!H) are distinct with the F_0 values for the three being approximately 250Hz, 210Hz, and 230Hz, respectively in the speech of a woman at normal speaking volume. A phonetic difference has also been established between a HLH and a H!H sequence indicating that the level of drop between a H and the following H in a HLH sequence is greater in hertz than that between a H and a !H in a H!H sequence making it necessary to re-examine the relationship

between low tones (floating or otherwise) and downstep high tones. In doing this, we recognize certain limitations of the study, one of which is the fact that the data was collected from two female Ibibio speakers from just two dialect areas. There may well be gender and dialect differences, and it would be interesting to find out what such differences would be. The other is the problem of deciding where to take F_0 values for the different tones given the dynamic nature of tones. At this point, the results here are very tentative until more data is collected from a cross section of speakers for an in-depth and clearer picture of the issues involved, although there is evidence to show that phonetics can shed some light on phonological issues and tonal problems are no exception.

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APPENDIX A

Data used for Experiment I

H-H	**ɔbɔŋ**	mosquito	**ukɔ**	burden	**ata**	type of insect
H-L	**ɔbɔŋ**	cane	**ukot**	in-law	**ata**	specialist
H!H	**ɔbɔɔŋ**	king	**uko**	there	**ata**	he has chewed
L-H	**ubɔɔŋ**	pumpkin	**uko**	valour	**ata**	sixty
L-L	**ɔbɔn**	type of masquerade	**uku**	charisma	**ataat**	wasp

APPENDIX B
Data used for Experiment II

1.	**ukarakpa ke se**	HHHHHH
2.	**se ebot ko**	HHHH
3.	**se ke ukot**	HHHH
4.	**ufɔk eto**	HHLHL
5.	**se akpɔk ye ikpa**	HLHLHH
6.	**se ete ye ata**	HLHLHL
7.	**efa ye eto**	HHLHH
8.	**ako ye uko**	H!HLH!H
9.	**uke ye uko**	H!HLH!H
10.	**a sat ɔkpɔ**	H!HHH
11.	**a top ufɔk**	H!HHHL
12.	**a fat eme**	H!HLL
13.	**a fɔp ita**	H!HLH
14.	**ete ye eta**	LHLLH
15.	**ata ye ikpɔ**	LHLHHL
16.	**ŋkarika ke i ta**	LLHLHLH
17.	**esɔ ke a ta**	LLHHH
18.	**akɔti ke a ta**	LHLHLH
19.	**utasi ye abasi**	LLLLLLL
20.	**a fɔp ata a fɔp ata a fɔp ata**	H!H!H!H!H!H!H!H!H!H!H!H!H
21.	**ndise ye utasi**	LLLLLLL
22.	**nturube ye utasi**	LLLLLLLL
23.	**ŋkanika ke ŋkanika ke ŋkanika**	HHHHHHHHHHHHHHH
24.	**utasi ye utasi ye utasi**	LLLLLLLLLLL
25.	**uko ye ako ye ɔbɔɔŋ ke uko**	LHLH!HLH!HH!H
26.	**ufɔk eko ke a tɔ etidot a do**	HHLHLHLHLHLHL
27.	**ukarakpa ke ukarakpa ke ukarakpa**	HHHHHHHHHHHHHHH
28.	**ŋkanika ye ŋkanika ye ŋkanika ye ŋkanika**	HHHHLHHHHLHHHHLHHHH
29.	**utasi ke esa ke a kippe**	LLLHLLHLLH
30.	**ekaete ye etete**	LLHLLLH!H
31.	**uke ye uke ye uko ye uko**	H!HLH!HLH!HLH!H