PHONETIC REALIZATION OF AUTOMATIC (DOWNDRIFT) AND NON-AUTOMATIC DOWNSTEP IN AKAN

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ABSTRACT

This paper deals with the question whether automatic and non-automatic downstep are distinct processes or can be regarded as the same phenomenon. Downstep is seen as a lowering of the pitch register, relatively to which tones are scaled. The distinction between the two types of downstep arises from differences in their tonal surface structure: In the case of automatic downstep a L(ow) tone intervening H(igh) tones triggers downstep (HLH); in the case of non-automatic downstep the L tone trigger is not realized phonetically (H!H, ! indicates downstep). Our controlled experimental data on downstep in Akan suggest that the degree of lowering is the same in both cases contrary to what has been claimed earlier in the literature.

Keywords: Akan, automatic downstep, non-automatic downstep

1. INTRODUCTION

This study reports on a comparison of the phonetic realization between automatic and non-automatic downstep in Akan, a two-tone language belonging to the Kwa branch of the Niger-Congo phylum, which is one of the major languages spoken in Ghana [13].

If the two types of downstep are phonetically identical, they share the same phonological trigger (a L tone), and can be analysed as one process. There has been a debate whether to treat the two as alike or as distinct processes (cf. e.g. [16, 18, 19] vs. [7, 15]), and in particular for Akan [7] claims that they are phonetically distinct. On the contrary [19] argues for an alike treatment. The present study will quantitatively address this issue by comparing the two types of downstep in identical sentence frames to avoid any influence from tonal structure or sentence length.

1.1. Previous work on tone in Akan

Akan exhibits a tonal contrast between lexical H and L tones, the tone bearing unit (TBU) is the syllable [6]. According to [6] Akan distinguishes three syllable types (V, CV, C), single sonorant consonants function as syllabic consonants, and any vowel constitutes a syllable, and in case of two adjacent vowels each of them constitutes its own syllable.

Akan has been classified as terraced-level tone language [1, 3, 19], which according to [3] displays a regular process of register shift. The register consists of reference lines relative to which local tonal targets are scaled. The shift of the pitch register affects the scaling of successive tones because it sets a new ceiling for tonal scaling while preserving the underlying phonological distinction.

The terracing property relates to downstep in the way that a H tone following a L tone is realized at a lower pitch level (automatic downstep, which is often called downdrift; see [5] for an overview). In the case of non-automatic downstep, or simply downstep, a similar lowering of H tones occurs, yet the triggering L tone is not phonetically realized. The underlying L tone is dissociated with its segmental material, e.g. by segmental deletion, and is often analysed as a floating tone [10]. An example of non-automatic downstep in Akan is given in (1a), which contrasts phonemically with a non-downstepped instance (1b) [6].

(1) a. ɔ̀bɔ́!fó - ‘messenger’
b. ɔ̀bɔ́fó - ‘creator’

In (1a) the last H tone is downstepped, and no overt L tone is realized prior to the downstepped H tone. This is analysed as lexical downstep, in which the downstepped H tone is part of the lexical entry of the word see a. o. [6] for Akan. [1] argues that instances of lexical downstep in Akan can be etymologically backtracked to exhibit a floating L̥. The L̥ tone triggers the following H tone to be lowered, a. o. [4].

If there is a floating L tone involved in the derivation of non-automatic downstep it is not to be treated as lexical downstep as [6] does and we would expect no phonetic difference between the two types of downstep since they have an identical L tone trigger.

1.2. Downstep in Akan

[7] examined the phonetic realization of automatic downstep (2a) and non-automatic downstep (2b) by recording 5 male speakers of Akan.[1] Her material for testing automatic downstep (2a) exhibits an alternating tonal make up of H and L tones. The first H tone (H_1) is preceded by a L tone; however the initial tone should not be affected by automatic downstep since it serves as frame setter [9]. The following H_2 and H_3 tones are subject to automatic downstep. The H tone following H_3 is not separated by a L tone and is therefore assumed to exhibit the same tonal height as H_3.

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(2)  a. L H1 L H2   L H3         HL  H4
        |  |  |  |    |  |          | |   |
      Pàpá   Kòfi  kɔ̀tɔ́           ńtòmá[2]
      Father Kofi  go_buy.PRS cloth
      'Father Kofi has gone to buy cloth.'
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(2)  b. LH1 H  !H2H    H   !H3H H  !H4
        | |  |    |  |    |     |  |  |     |
      Kòfí   á-!bɛ́ká   á-!kyérɛ́ Á!má
      Kofi   PRF-come PRF-tell  Ama
      'Kofi has come to tell Ama (about it).'
```

Non-automatic downstep in (2b) shows downstep on H_2, H_3, and H_4.[3] [7] calculated the pitch drop between the H tones. The results are summarized in table 1. The comparison of differences in pitch drop in table 1 reveals that there is a 10 Hz bigger drop between H_1 and H_2 and a 10 Hz smaller drop between H_2 and H_3 for automatic downstep. The values are relatively stable for non-automatic downstep. [7]'s conclusion is that non-automatic downstep shows a greater degree of lowering than automatic downstep.

Table 1: F0 values in Hz and differences in pitch drop for automatic and non-automatic downstep, data from [7].

	automatic DS		non-automatic DS	
	H in Hz	Δ	H in Hz	Δ
H_1	181		180	
		31		25
H_2	150		155	
		10		20
H_3	140		135	
		20		20
H_4	120		115	

The sparse literature leaves us with conflicting results for Akan with [19] claiming identical phonetic realization, and [7] promoting a difference with a greater degree of lowering for non-automatic downstep.

1.3. Downstep in other tone languages

Two instrumental studies on Igbo (Kwa) show conflicting results, too. [15] reports that automatic downstep causes a significantly greater degree of lowering than non-automatic downstep. Whereas [12] concludes that both types exhibit the same amount of lowering.

[16] examined the phonetic realization of downstep in Bimoba (Gur). Both L and M tones cause H tones to be downstepped. No phonetic difference between the two types of downstep was observed. Also for Chumburung (Kwa) [18] concludes that the degree of lowering is the same and that his findings support theories which equate automatic and non-automatic downstep (e.g. [9, 17]).

2. METHOD

2.1. Speech materials

We embedded two target words (3), causing different downstep types, into the same carrier sentence (4). In the case of automatic downstep (3a) the L tone is present at the surface. In the case of non-automatic downstep (3b) the nominal prefix ɔ̀ is deleted, and the L tone dissociates. The floating L tone triggers downstep on the following H tone.

```
(3)  a. Automatic downstep:
        kòfí  + pàpá   →    kòfí   pàpá
        Kofi    father      Kofi's father
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(4)  b. Non-automatic downstep:
        kòfí + ɔ̀-dáń   →    kòfí   !dáń
        Kofi   N-house      Kofi's house
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(5)  LH1L  L L      LH2 !HH3 H L  H    H
     | | |  | |      | |   | |  | | |     |
     Àfúà hùnù     Kòfi  dá ń   ánɔ̀pá   yí
     Afua  see.PRS Kofi  house  morning this
     'Afua sees Kofi`s house this morning.'
```

2.2. Procedure

Six native speakers of Akan (5 male, 1 female) participated in the experiment. Their average age was 28. All speakers declared English as their second language.

The experiment was carried out, using presentation software, in Akan script; since it does not mark tones an English translation was given below the text. Items from two other unrelated experiments were interspersed as fillers. Participants were digitally recorded at a sampling frequency of 44.1 kHz and 32 bit resolution, on a laptop (Levono R61) using Audacity (Version 1.2.6) and a headset (Logitech Internet Chat Headset). The microphone was an electret condenser type with a sensitivity of -39 dbV/Pascal.

Each test sentence was repeated three times which results in a dataset of 36 sentences (6 speakers x 2 downstep conditions x 3 repetitions).

2.3. Data pre-processing, statistical analysis

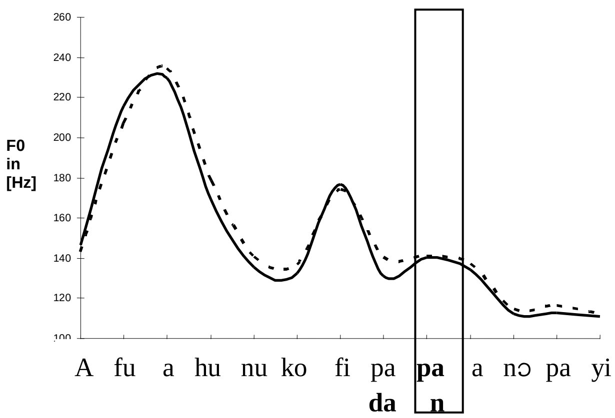
The syllables of all sentences were labelled by hand in Praat [2], and boundaries were set automatically at zero crossings. The F0 analysis was based on a Hanning window of 0.4 seconds length with a default 10 ms analysis frame. Algorithm faults were manually corrected. The F0 was smoothed at 10 Hz to diminish microprosodic perturbations. Tones were labelled for each syllable. The tonal marker was set manually in the middle of each of the tone bearing vowels. The corresponding F0 was extracted in Hz.

The statistical analysis relied on the dependent variable ‘F0’. A paired samples T–test was carried out in R.

3. RESULTS

Figure 1 visualizes the time normalized course of F0 for the test sentence (4) with target words containing either automatic (solid line) or non-automatic downstep (dashed line). The crucial part of the target word, i.e. the second syllable carrying the downstepped H tone, is highlighted in bold and by a box.

Figure 1: Time-normalized course of F0 by syllable for sentence (4), aggregated for all speakers (n=6). The solid line corresponds to automatic downstep and the dashed line to non-automatic downstep.



The curves are nearly lying upon each other. The automatically downstepped H tone on the second syllable of the target word *pàpá* is realized at a mean F0 of 140 Hz (SD=36.5). The non-automatically downstepped H tone of the first syllable of the target word ***dá**ń* exhibits a mean F0 of 140 Hz (SD=27.8). The paired samples T-test did not reveal a significant difference ($t(5) = 0.002$, $p = .998$).

The first syllable of the target word *dá**ń*** defines a new register for H_3 (4). We compare the second syllable of both words to exclude any positional effects. H_3 on the second syllable of the target word *dá**ń***, is realized at a mean F0 of 141 Hz (SD=27.8). The paired samples T-test did also not show a significant difference between the two H tones ($t(5) = 0.09$, $p = .932$), cf. the box in Fig 1.

Table 2: F0 values in Hz and differences in pitch drop for automatic and non-automatic downstep.

	H in Hz	Δ	H in Hz	Δ
H_1 automatic DS	230	53	235	61
H_2 automatic DS	177	37	174	33
H_3 automatic DS/non-automatic DS	140		141	

To compare our results with those of [7] we calculated pitch drops between the H tones (table 2). Contrary to [7] the amount of drop in pitch is similar between the two types of downstep, and does not differ significantly ($t_{H1H2}(5) = 1.3$, $p = 0.25$; $t_{H2H3}(5) = 0.5$, $p = 0.64$).

4. DISCUSSION

Comparing the phonetic realization of automatic and non-automatic downstep in Akan we show that there is no phonetic difference between the two in line with [19] and in opposition to [7]. In contrast to earlier studies we compared the two types of downstep by embedding target words in an identical sentence frame in order to exclude any influence of sentence length or tonal configuration.

The drop in pitch is generally greater in the beginning of an utterance. This follows from the fact that Akan is a terraced level language in which an utterance is subject to a gradual lowering process [3]. The pitch register decreases over the course of an utterance.

In [7] the pitch drop in the beginning of the automatic downstep case is on average 5 Hz bigger than for non-automatic downstep (cf. table 1). Our calculation of paired samples T-tests for the absolute pitch levels reported in [7] reveals no significant difference between automatic and non-automatic downstep for any of the three H tones

($t_{H1}(4) = 0.6$, $p = 0.56$; $t_{H2}(4) = 1.8$, $p = 0.15$; t_{H3} $(4) = 2.3$, $p = 0.083$).

The second pitch drop between H_2 and H_3 is smaller in the case of automatic downstep, which according to our calculation is significant ($t(4) = -7.8$, $p = 0.001$). Hence the difference between automatic and non-automatic downstep reported in [7], refers only to the second drop in pitch; to our view the difference in absolute Hz values is rather due to variation in speech production. The exact reason for the difference in the second drop remains unclear.

However, our study based on controlled data provided evidence that there is only one process of downstep in Akan, which is in line with [12, 16, 18, 19]. The conclusion is based on two measures, (i) the absolute pitch level, and (ii) the pitch drop between H tones.

Though one could be tempted to say that downstep is solely automatic and therefore a phonetic by-product of the tonal configuration there are languages such as English [14] and German [8] where no L tone downstep trigger is present, neither an underlying one nor one on the surface.

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[1] The speech data of the present study and that of [7] comes from Asante Twi, the major dialect of Akan.

[2] Transcription, association lines and glossing added to the original.

[3] According to [7] H_2 and H_3 are derived from !H tone spreading, while H_4 is an instance of “lexical downstep”. The underlying L tone of the infinitive *bɛ̀ká* ‘come to tell’ causes downstep on the following H tone; this …”!H tone spreads to the preceding low tone syllable, that is, tone spreading is left to right.” [7] p.4. If spreading occurs in this direction the surface form in (2b) cannot be derived. Since [7] talks about spreading to the preceding tone, the spreading direction can only be right to left which is typologically very uncommon [11]. On this H tone, however, the difference between the two types of downstep becomes apparent (cf. table 1). We leave the exact analysis of this kind of downstep open for further research.