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Final lowering in non-final position

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Abstract

This article argues that a factor contributing to final lowering in intonation is that H tones preceding downstep are scaled higher than H tones not preceding downstep, all else being equal. Final lowering is argued to be (in part) the absence of this effect with the last element of a sequence of downstepped tones. The evidence comes from intonation data recorded with speakers of German from Southern Germany and Austria. In two structures, a sequence of downstepped prenuclear pitch accents $PA_1!PA_2\ldots!PA_{n-1}$ is continued with a nuclear pitch accent PA_n that is not downstepped. In both structures, final lowering is found on the last downstepped pitch accent PA_{n-1}, crucially in penultimate position of the intonation phrase. Here potential triggers for final lowering in the environment are not present (phrase-final position) or present only in one structure (a following *L*% boundary tone). The application of final lowering in these cases shows that there is a factor contributing to final lowering that affects accentual tones not followed by downstep, regardless of the environment.

Keywords: Intonation; Final lowering; Downstep; Upstep

1. Introduction

Liberman and Pierrehumbert (1984) have established two important generalizations in respect of the phonetic course of English sequences of downstepping pitch-accents. First, in downstep among non-final accents, the amount of lowering decreases with each step in a way that can be plausibly modeled by exponential decay towards an abstract reference-line. Second, given such an account of non-final accents, the final accent is considerably lower than expected. Liberman and Pierrehumbert (1984) call the latter effect *final lowering*, and model it as an effect of lowering overlaid in final position. This effect is schematically illustrated in Fig. 1.

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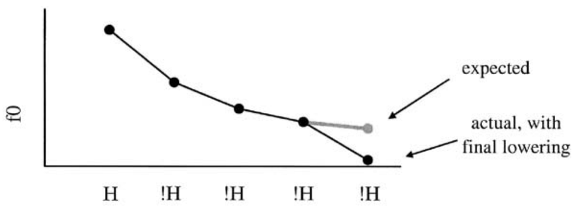

Fig. 1. Idealized illustration of downstep of H values as exponential decay, and final lowering on a final H tone as a drop in f_0 relative to the expected continuation of this course. After Liberman and Pierrehumbert (1984).

Following Pierrehumbert (1980), Liberman and Pierrehumbert (1984) present an account of downstep sequences within a model in which phonetic values are calculated from left to right. The material they analyze does not provide evidence for preplanning such that it would be an inherent part of speaking ('hard preplanning'; they allow for 'soft preplanning', depending on considerations of particular speakers).

Dramatic effects of final lowering at the end of downstep sequences have also been documented in Mexican Spanish in Prieto, Shih, and Nibert (1996), in sequences of high pitch-accents. Final lowering has been documented in the tone-language Yorùbá by Laniran (1992), in downstep sequences of alternating (lexical) H and L tones. In Laniran's Yorùbá data, final lowering is particularly clear in utterance-final position. There are some indications in Laniran's data that final lowering also applies preceding a medial reset, and this issue will be taken up briefly at the end of this article. Final lowering has also been documented in the tone-language Kipare by Herman (1996).

Downstep and final lowering are sometimes discussed in connection with declination, yet another regularity that has been argued to lead to f_0 lowering. In the understanding of declination adopted here from Pierrehumbert (1980) and later literature, declination is a global and time-dependent downward trend effective in addition to other downtrends such as downstep. In the metaphor of Pierrehumbert (1980), declination may be thought of as downward tilted graph-paper in which the phonetic values are plotted. The tilt makes later values appear relatively lower than earlier values, everything else being equal. The values plotted in this graph-paper then depend on choice of tone (H vs. L), downstep, and other factors.

The model of downstep in Pierrehumbert (1980) and Liberman and Pierrehumbert (1984) predicts that the amount of lowering induced by downstepping between two H tones is independent of the temporal distance between the two H tones. When declination is added to the picture, the temporal distance may affect the amount of lowering between two such H tones: a greater temporal distance will absorb a relatively larger fraction of the overall declination of the utterance. The effect of temporal distance in downstep sequences was investigated in Prieto et al. (1996) and in Grabe (1998), with different findings. Prieto et al. (1996) found in their Mexican Spanish downstep data that there was no significant link between the extent of downstepping and the duration between two pitch accents. The authors present these findings in support of the model of downstep in Liberman and Pierrehumbert (1984) in which the height of a preceding peak, but not its temporal distance, predicts the height of a downstepped tone. Grabe (1998) finds in her downstep sequences with British English speakers that temporal distance affects the amount of f_0 lowering, which bears out the predictions of a model that overlays downstep and declination.

With regard to declination and final lowering, the evidence for declination from Pierrehumbert (1980) has early on been subsumed under final lowering in the model of Liberman and Pierrehumbert (1984). Later, other kinds of evidence for declination have been found that cannot be subsumed under final lowering, suggesting that declination is an independent phenomenon (Gussenhoven & Rietveld, 1988; Pierrehumbert & Beckman, 1988; Shih, 2000). The possibility of (inversely) subsuming the evidence for final lowering in Liberman and Pierrehumbert (1984) under declination is explored by Grabe (1998). The present study takes as a starting point that final lowering cannot be subsumed under declination. The starting point is motivated by the fact that in Laniran (1992) and Prieto et al. (1996), there is no systematic reason to believe that the temporal distance among the accents would vary in a way that could provide a basis for such an explanation. The independent status of final lowering will also be empirically substantiated in the German data discussed below.

The present study bears on what factors contribute to final lowering. Liberman and Pierrehumbert (1984) write the rule for final lowering below, which has the following interpretation: The height of target P above the reference-line r is reduced by a factor l in final position.

Final lowering (Liberman & Pierrehumbert 1984, p. 192)

$$P \rightarrow r + l(P - r)/\_\$, \qquad \text{where} \quad l < 1.$$

If one takes '$' to stand for the end of a prosodic domain such as the intonation phrase or utterance, this rule reduces the height of the last pitch accent in that prosodic domain. (Liberman and Pierrehumbert (1984) also point out other formulations of final lowering, and further point out the possibility that final lowering is an entirely phonetic effect resulting from properties of the speech production system.)

A different approach to the trigger is suggested in connection with a comparison of declaratives and questions in the study of Tokyo Japanese in Pierrehumbert and Beckman (1988, p. 72ff). Pierrehumbert and Beckman (1988) compare declaratives and questions with identical tonal specifications in non-final positions, but with different final boundary tones: the declaratives end with a final L% edge tone, while the questions are delimited by a final sequence of L%H% edge tones. The tones preceding this final sequence show phonetic differences, being higher in the questions than in the declaratives. This apparent right-to-left effect goes as far as the last accented element for one speaker, and even further leftward for another. Pierrehumbert and Beckman (1988) classify this effect as final lowering, and outline two similar accounts in which either an utterance-level L% of the declarative or the utterance-level H% of questions has an assimilatory phonetic effect on the height of earlier tones. (The postulated effect is nonlocal on the surface, but local in terms of a more abstract formal account they develop.) While the source of evidence for final lowering is the comparison between questions and statements here, Pierrehumbert and Beckman (1988) indicate that they seek an account that carries over to final lowering at the end of downstepping sequences. Such an account would thus maintain that the last in the sequence of downstepping values as in Fig. 1 might likewise undergo final lowering under the nonlocal influence of a final phrase- or utterance-level L% tone.

The experiment reported on here is conducted with speakers of German. Experimental investigations of German intonation in the framework of Pierrehumbert (1980) and later literature were made by Uhmann (1991), Féry (1992, 1993), Grabe (1998), Fitzpatrick-Cole (1999), Barker

(2002), and Kügler (to appear). For suggestions for German ToBI transcriptions, see Grice, Reyelt, Benzmüller, Mayer, and Batliner (1996), Grice and Baumann (2002), Grice, Baumann, and Benzmüller (in press). Downstep in German has first been documented by Féry (1993) and studied in Grabe (1998), both in connection with H* + L pitch accents. Final lowering in German has been investigated by Grabe (1998).

Relevant to the present study is an intonation pattern of successive accentual rises in which the stressed syllable is perceived as low. These have been analyzed as L* + H in the literature cited in the preceding paragraph. Pierrehumbert (1980) had earlier observed that L* + H sequences are downstepping in English, and downstep among such L* + H rises in German dialects has been observed by Fitzpatrick-Cole (1999) in Bern Swiss German, and Barker (2002) in Tyrolean German.

The present study tests for final lowering in a new environment. In German, a sequence of prenuclear downstepped L* + H pitch accents may lead up to a nuclear pitch accent that is arguably not downstepped (see Truckenbrodt (2002); for possibly related cases in English see Beckman and Pierrehumbert (1986, p. 298f) and Ladd (1983a, p. 735), for possibly related cases in German see Féry (1993, p. 159f) and Fitzpatrick (1999), the latter concerned with Bern Swiss German). One case of this kind is seen in a phonetic plateau extending between the penultimate accented syllable and the final accented syllable. It may be analyzed as the tonal sequence L* + H H + L* of a prenuclear and a nuclear pitch accent, the latter apparently restricted to utterance-final position. A possible tonal configuration of an intonation phrase is thus [L* + H L* + !H…L* + !H H + L*]. A second case of this kind is found at the end of a non-final intonation phrase, where some speakers use a nuclear upstepped L* + ^H that does not continue the course of prenuclear downstepping L* + H pitch accents. Here a possible tonal configuration of an intonation phrase is [L* + H L* + !H…L* + !H L* + ^H]. The recordings on which the present study draws (in the two-clause condition; see below) are evaluated for this upstep phenomenon in Truckenbrodt (2002). There it is argued that the upstepped nuclear pitch accent in this intonational pattern is scaled independent of preceding downstep. In both these cases, then, the penultimate pitch accent (L* + H) is followed by a nuclear pitch accent not downstepped relative to the penultimate pitch accent.

The question of interest in the present study is whether some amount of final lowering occurs on the penultimate pitch accent in these cases, which is the last one among the downstepped pitch accents, but is not in intonation-phrase final position. To the extent that such final lowering in non-final position is found, it is evidence for a component of final lowering that is narrowly tied to the distribution of downstep, rather than triggered by phrase-final position or later edge tones.

2. Method

2.1. Stimuli

The materials of the experiment consist of one-clause stimuli and two-clause stimuli. The one-clause stimuli constitute the test-case involving the final plateau ((…) L* + H H + L*). There are five series of one-clause stimuli. The four series (a.-d.) have an increasing number of accents, from two to five, as illustrated below. The names of the series are retained in later discussion.

('SU': subject, '& SU': a second subject conjunct, 'Aux': auxiliary verb, 'IO': indirect object, 'PP': PP adjunct, 'DO': direct object, 'V': final main verb, 'CP': clause). Underlined elements were expected and found to regularly carry accents.

a. [SU Aux DO V]$_{CP}$
b. [SU & SU Aux DO V]$_{CP}$
c. [SU & SU Aux IO DO V]$_{CP}$
d. [SU & SU Aux IO PP DO V]$_{CP}$

A further series (c′) was included so as to be able to assess any effects of syntactic branching on tonal scaling (Ladd & Johnson, 1987; van den Berg, Gussenhoven, & Rietveld, 1992). Series (c) and (c′) have an equal number of accents, but are syntactically distinct. Series (c) has initial subject coordination, followed by right-branching syntactic structure. Series (c′) lacks the initial subject-coordination and has a consistently right-branching syntactic structure:

c. [[SU & SU] [Aux [IO [DO V]]]]$_{CP}$
c′. [SU [Aux [IO [PP [DO V]]]]$_{CP}$

An example from series (d) is given below. The expected positions of accents are indicated by underlining. The accompanying accent domains (see below) are given by round brackets. The square brackets indicate the expected intonation phrase (Beckman & Pierrehumbert, 1986; Nespor & Vogel, 1986), corresponding to a CP clause.

SU & SU Aux IO PP DO V
[(die Manu) (und die Hanne) (sollen der Lena) (im Januar) (das Leinen weben)
'Manu and Hanne are supposed to weave the linen for Lena in January.'

The expectation about the prosodic structure in German is based on Gussenhoven (1983, 1992), as developed by Uhmann (1991) in some detail. (Gussenhoven's original version is adopted here, and borne out by the materials, in regard to the obligatory nature of domain-assignment within a larger focus; see also Féry, 1993). By Gussenhoven's *Sentence Accent Assignment Rule*, each syntactic argument (here: SU, IO, DO) and adjunct (here: PP) forms an accent domain (see Ladd (1983b) for this terminology) with an accent. The final verb that follows the DO does not receive an accent in this account (more generally, predicates adjacent to an accented argument do not receive an accent and are instead included with the accent domain of that accented argument). Auxiliary or modal verbs in sentence-second position are not accented in the Dutch and German examples in Uhmann (1991), Gussenhoven (1992), and Féry (1993), and are here grouped with an accented element following at a short distance, adopting a refinement of Bierwisch (1966) by Uhmann (1991, p. 236). Coordinated constructions such as [SU & SU] are not discussed by Gussenhoven or Uhmann, though a reasonable extension of the algorithm will assign two accent domains (SU)(&SU) in such cases. See also Jacobs (1993, 1999), Selkirk (1995), and Büring (2001) for discussion of facts comparable to those covered by Gussenhoven's rule, in different terms. The position of the nuclear stress (the last and presumed strongest accent in the intonation phrase) in examples of this kind is also uncontroversial following various studies on main stress and focus in

German (Höhle, 1982; Pheby, 1981; Selkirk, 1984; Cinque, 1993; Zubizarreta, 1998, among others). The expectations about accent assignment were applied with some confidence in the experiment, due to a number of preceding pilot studies on intonation by the author and students of his.

Each series (a)–(d), (c′) is represented by four different sentence stimuli. These were each read three times by the subjects, for a total of 12 tokens per series per speaker.

The two-clause stimuli provide the test-case for final lowering preceding the nuclear upstep ((…) $L^* + H\ L^* + {}^\wedge H$) at the end of the first clause. There are four series (a)–(d). As shown below, the first clauses mirror the different syntactic and prosodic structure of series (a)–(d) of the one-clause stimuli. The second clause is connected by sentential coordination with *und*, '*and*'.

a. [SU Aux DO V $]_{CP}$ & [XP (XP) XP $]_{CP}$
b. [SU & SU Aux DO V $]_{CP}$ & [XP XP XP $]_{CP}$
c. [SU & SU Aux IO DO V $]_{CP}$ & [XP XP XP $]_{CP}$
d. [SU & SU Aux IO PP DO V $]_{CP}$ & [XP XP XP $]_{CP}$

An example from series (d) is shown here, again with the expected prosodic structure indicated. The coordinated root clauses are expected to forms separate intonation phrases, following a cross-linguistic generalization of Nespor and Vogel (1986).

SU & SU Aux IO PP DO V
[(die Manu) (und die Lola) (wollen dem Werner) (im Januar) (ein Lama malen)]
'Lena and Lola want to paint a llama for Werner in January …'

& SU Aux PP DO V
[(und die Manu) (soll im November) (Bananen essen)]
'… and Manu is supposed to eat bananas in November.'

In the two-clause condition, each series (a)–(d) was represented by six stimulus sentences. These also were read three times by each speaker. The two-clause condition thus contains a total of 18 token recordings for each series for each speaker. The list of all stimuli is given in the appendix.

2.2. Speakers and recordings

One speaker, SW, is a colleague of the author. Eleven other speakers were recorded, all students at the University of Tübingen. Subjects were recruited with a flier, and were remunerated for their time. Four speakers were not included in further evaluations in Truckenbrodt (2001, 2002) and the present article. One of them showed no regularity in the scaling of rises (in particular no downstep or upstep), one of them turned out to be bilingual, and two others preferred to read the two-clause condition without a rise at the end of the first clause on either the last pitch-accent or at the boundary. The findings below draw on the remaining eight speakers that are also the basis of evaluation for Truckenbrodt (2001, 2002). Of these, SW participated in recordings of the two-clause condition only.

The speakers grew up in dialect areas characteristic of a Southern German variety. Four come from the Swabian part of Baden-Württemberg in Germany (AT is from the area of Sigmaringen, BK is from Pforzheim, NA is from the area of Göppingen, and MG from the area of Reutlingen), two come from the Alemannic area of Baden-Württemberg (CB is from the area of Ravensburg and TL lived in Waldshut, Lörrach, and the area of Achern before he was 18), and two others are from different parts of Austria (SW is from Villach and FS from Graz). The Southern dialects of German are known to typically show intonation patterns that are perceived as low on the stressed syllables, as in the findings of Kügler to appear (Stuttgart Swabian), Fitzpatrick (1999) (Bern Swiss German), and Barker (2002) (Tyrolean dialects). Speakers from further North in Germany, on the other hand, are known to also frequently use intonation patterns perceived as high on the stressed syllables, as do the speakers used in the studies of Uhmann (1991), Féry (1993), Grabe (1998) (Braunschweig), and Peters (2002) (Hamburg). Speakers AT, FS, NA, and SW are female, speakers BK, CB, MG, and TL are male.

The sentences of the one- and two-clause conditions were together presented on a computer print-out in pseudo-randomized order. The sentences were elicited in a manner intended to avoid expressive use of intonation and narrow focus on any element of the sentence. This was achieved by a combination of presentation of the stimuli and instructions prior to recording. On the print-out, each sentence was preceded by the context question *Was gibt*'*s Neues*, '*What*'*s new*?', which was read by the experimenter prior to the reading of the sentence by the subject. Prior to recording, the subjects were informed that the interest in the experiment was with the sentence melody. The subjects were made aware with an example (narrow sentence-initial focus) that 'special emphasis' can affect the melody of a sentence, and were told that such special emphasis was not of interest in the experiment. They were asked to read the sentence as an answer to the context question, and were told that the context question was intended to discourage the assumption that any one part of the sentences may be more important than the others. Further, this interest was said to extend to multiple occurrences of the same character (Lena, Lola, etc.) across sentences: The sentences were to be read as though each character was new each time. The speakers were further made aware that 'emotional' factors such as incredulity can affect the sentences melody, and were given a questioning rendition of a statement as an example. They were told that such emotional factors were not of interest in the experiment, and that a normal, narrative rendition was of interest. The speakers later followed these instructions with what appeared to be natural ease. As a final part of the instructions, speakers were told that they could ask for a repetition of a sentence, which would then include a repetition of both context question and answer, in case they felt that their rendition was not natural or fluent. All speakers made some use of that option. In those cases, only the final repetition was analyzed. About 10 question–answer pairs were read initially to familiarize the subject with the process. After that, the recordings were started. The sentences were read three times, with pauses between recordings. The recordings lasted for about 20 min for each speaker.

Speaker SW read sentences of the two-clause condition but not the one-clause condition, with the same context and instructions. The sentences of the two-clause condition read by this speaker conform to the description of the experiment given above; some of the sentences read by this speaker differ in detail from the sentences used for the other speakers; see the appendix for these details.

The recordings were made on a DAT tape-recorder in a quiet room. They were later analyzed using ESPS/waves +. The analysis included labeling with the help of a spectrogram, and f_0 measurements as detailed in the following section.

2.3. Tonal patterns and criteria for measurements

This section describes the relevant f_0 patterns and the measurement criteria that were applied for assessing downstep and final lowering.

One f_0 pattern is a rise regularly occurring in positions of prefinal accents in both one- and two-clause condition. Fig. 2 shows examples in which the rise is followed by a fall towards a subsequent rise. (The fall but not the subsequent rise is shown here.) Compatibly with the results on Southern German by Atterer and Ladd (2004), the rise showed its initial f_0-minimum on average early in the stressed syllable. A measurement was made of this f_0-minimum at the onset of the rise. The stressed syllable was followed by at least one more syllable in the same word in the stimuli. The end of the rise was usually found in this following syllable. As shown in Fig. 2, the

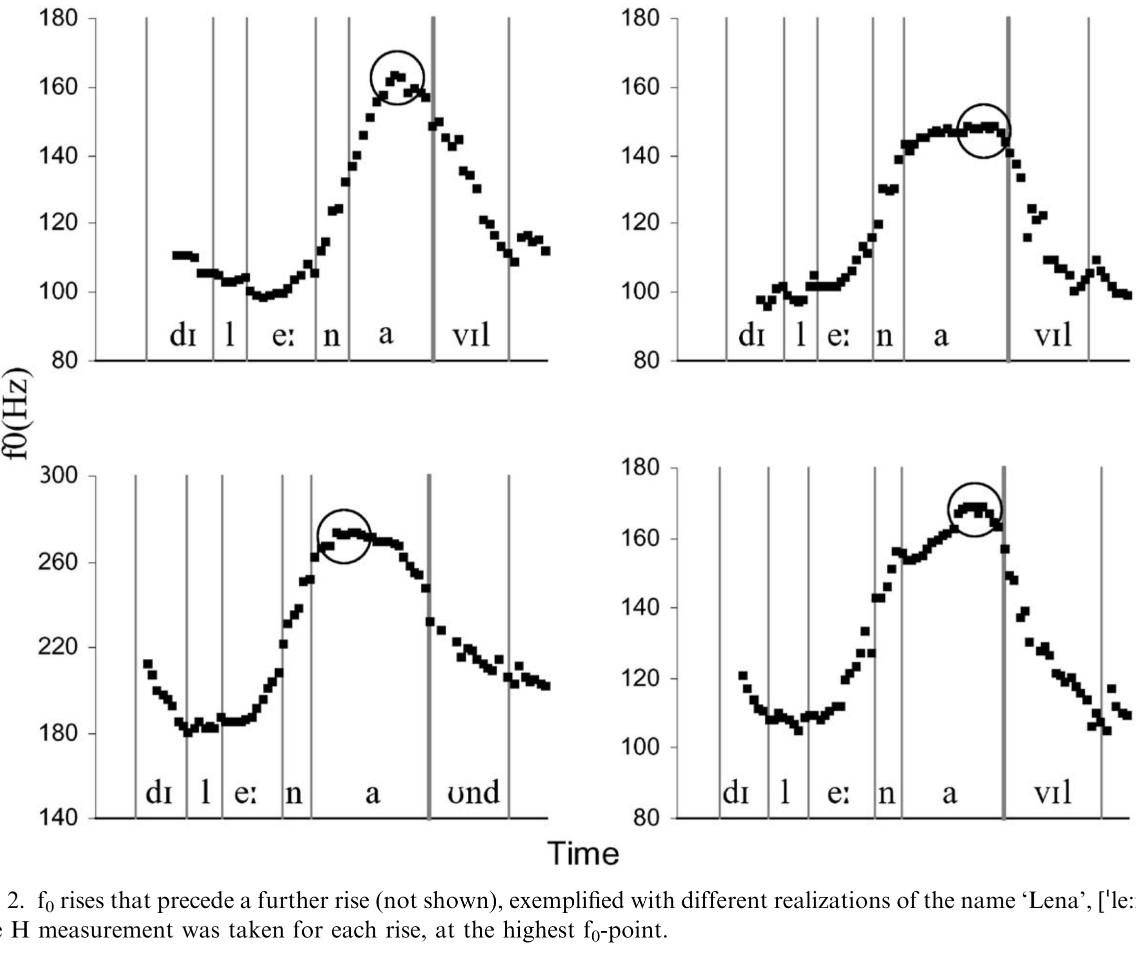

Fig. 2. f_0 rises that precede a further rise (not shown), exemplified with different realizations of the name 'Lena', ['le:na]. One H measurement was taken for each rise, at the highest f_0-point.

rise is sometimes followed by a plateau-like shape that extends to the end of the accent domain. In some cases, the 'plateau' was slightly falling or rising, or more steeply rising. As indicated in Fig. 2, one measurement for an f_0-maximum was taken for each rise, at the highest point between the onset of the rise and the fall toward the beginning of the next rise. This always occurred within the accent domain in which the rise originated. An effort had been made in the construction of the stimuli to avoid obstruent sounds, particularly voiceless obstruents, in the position of expected f_0-maxima (in the sounds between the nucleus of a stressed syllable and the right edge of its accent domain). Consequently, there were very few obvious microprosodic consonantal distortions to the f_0-maxima. In a few cases, in which a voiced obstruent introduced such a distortion after all, a plausible measurement could normally be made in an area that was judged to be outside of the distortion; if that was not the case, the measurement was skipped.

In utterance-final position, the penultimate accented syllable showed a rise that likewise originates early in the stressed syllable and terminates before the end of the corresponding accent domain. For most speakers, this is followed by a plateau, as shown in Fig. 3. The end of the plateau is marked by a steep fall that ends within in the last stressed syllable.

f_0-minimum measurements were taken at the low turning points preceding the rise to the plateau and following the fall after the plateau. f_0-maximum measurements were taken at the beginning of the plateau, preceding the accent domain boundary, as well as towards the end of the plateau, at a high point as much to the right as possible, but still preceding the recognizable onset of the following fall. While the rise in penultimate stressed position occurred with few exceptions before the accent domain boundary, the continuation as a plateau showed occasional variation. As illustrated in Fig. 4, there was sometimes a (small) step downward between first and second part of the plateau, and in a few cases no discernible continuation as a plateau. Measurements were skipped in the few cases of a missing clear onset of the plateau, and measurements were skipped in the absence of a clear turning point at the end of the plateau.

For the purpose of this article, a phonological analysis is sufficient that assigns a L+H accentual rise in prefinal position, and a H+L accentual fall in utterance-final position. The utterance-final plateau is constituted by the H tones of the final two pitch accents in the sequence L+H H+L. The plateau occasionally found with a rise that precedes other rise is attributed to the additional presence of an H_{ad} edge tone of the accent domain, for a more complete specification of the prefinal rises as L+H H_{ad}.

The measurements of the turning points described are taken to be measurements of the tones of the preceding phonological analysis. The limitation to a single measurement in the assumed sequence L+H H_{ad} is justified with the estimation that the two H tones here share a tonal target (they are not separated by downstep, for example), and that the measurement of the highest peak seems to be the best approximation to the shared target.

In the following, the L+H rise is transcribed as L^*+H and the H+L fall as $H+L^*$. This is compatible with the timing of the f_0-maxima and f_0-minima described above, and with the perception of the accented syllable as low in both the rise and the fall. This transcription puts the rise in the same phonological category as the L^*+H postulated for different varieties of German in Uhmann (1991), Féry (1993), Grabe (1998), Fitzpatrick (1999), Barker (2002), and Grice and Baumann (2002). See Atterer and Ladd (2004) for critical discussion of the assignment of the star in connection with German rises. A German $H+L^*$ pitch accent with properties compatible with the fall found here is postulated in Grice and Baumann (2002).

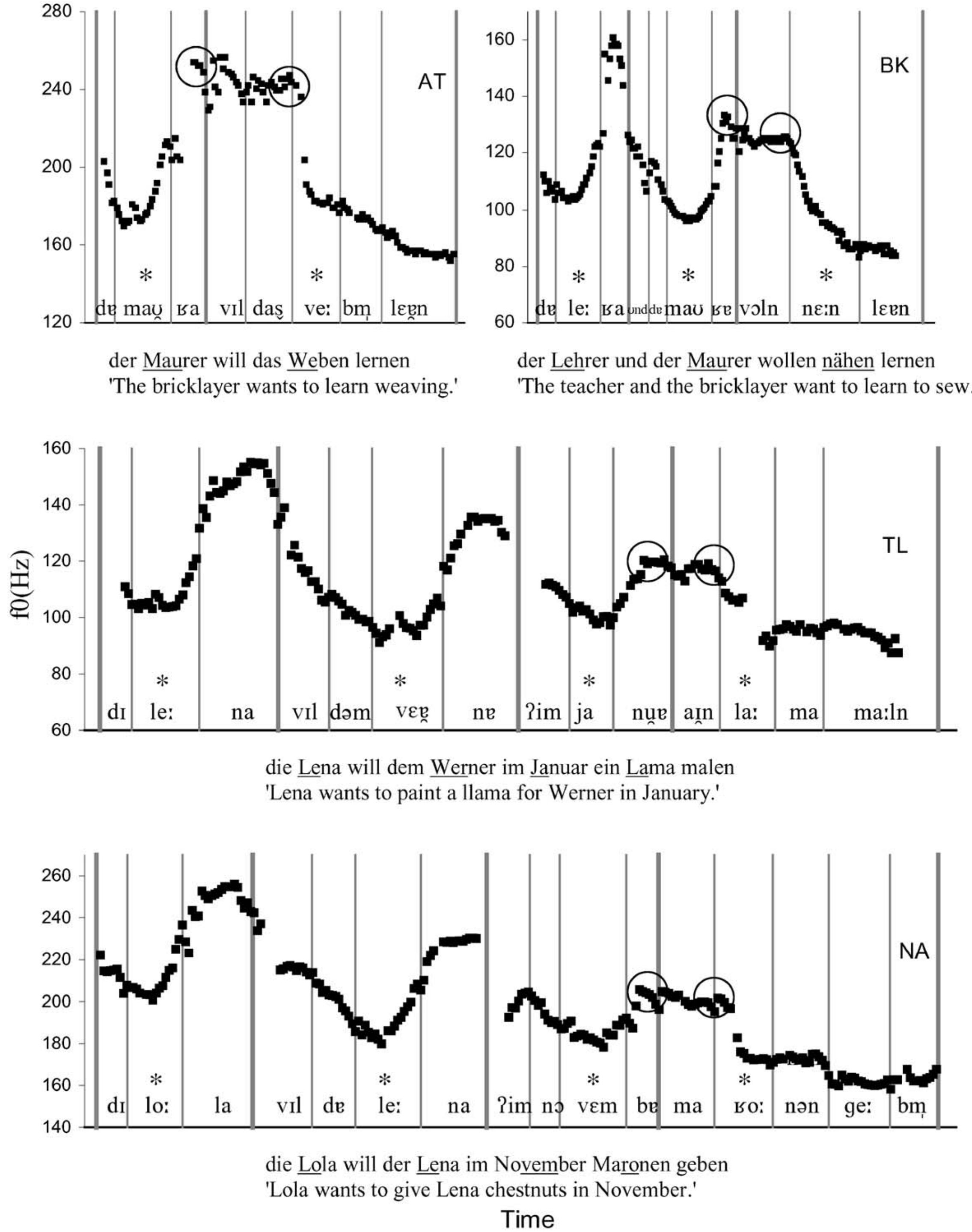

Fig. 3. Illustrations of the plateau between the last two accented syllables in the one-clause condition. Accented syllables are highlighted with a star and assumed accent domains are separated by thick vertical bars. The subject is shown by a code in the right of each display.

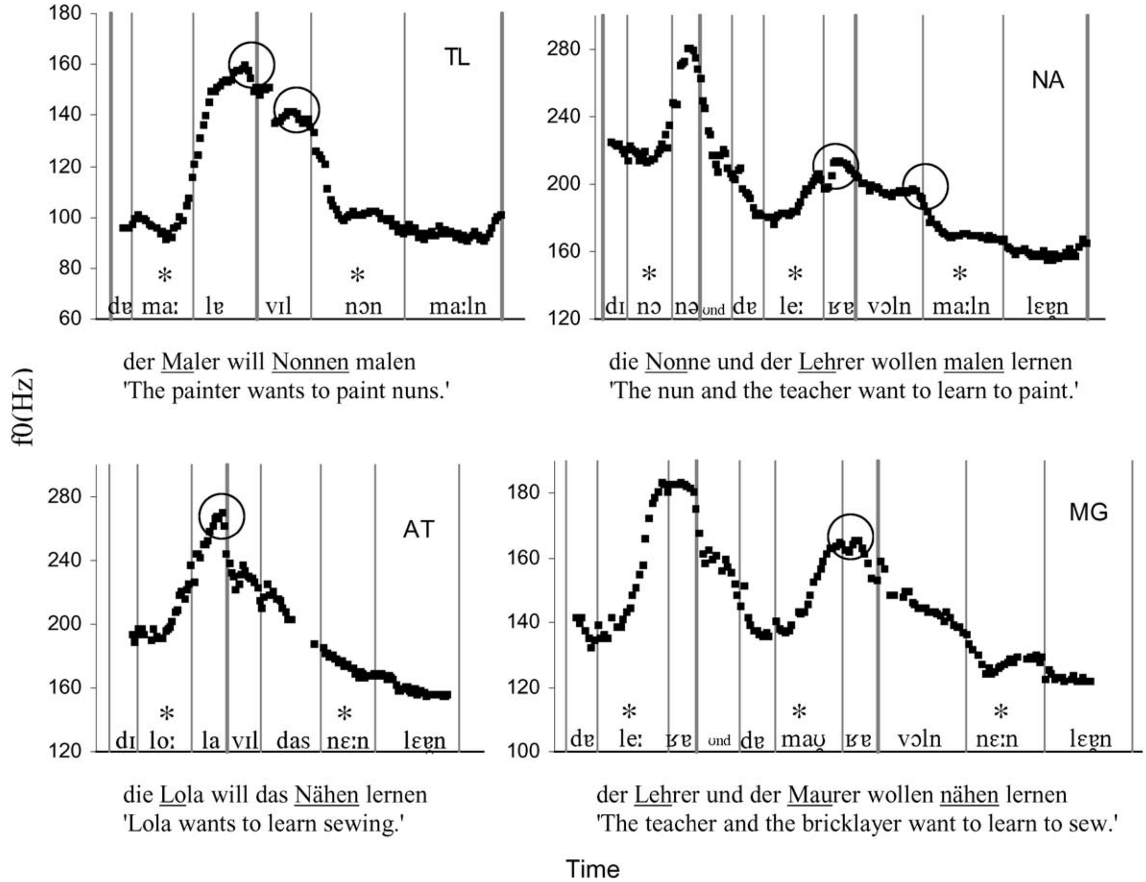

Fig. 4. Illustrations of f_0-lowering within the final plateau, and of cases with no clear evidence for a further H tone after the rise in penultimate position.

3. Results

3.1. Final lowering in non-final position in the one-clause condition

All speakers realized the positions of anticipated prenuclear accents with rises (with few exceptions), i.e. with the $L^* + H$ (H_{ad}) sequence of the phonological analysis. In utterance-final position, five speakers (AT, BK, MG, NA, TL) produced the plateau which is analyzed here as $L^* + H\ H + L^*$. Speaker CB showed no clear evidence for a tone associated with the final stressed syllable apart from an L^* pitch accent in utterance-final position. Speaker FS used a rise in final position that is classified as $L^* + H$ by the same criteria used in prefinal positions.

Fig. 5 shows the averaged measurements from the one-clause condition for speakers AT, BK, CB, MG, NA, and TL. (Speaker FS, with a final rise, is discussed separately below.) Plots with measurements of both L and H values are given on the left; the plots on the right omit the L values and use a different scale. Inspection of the H values reveals effects of downstep among the

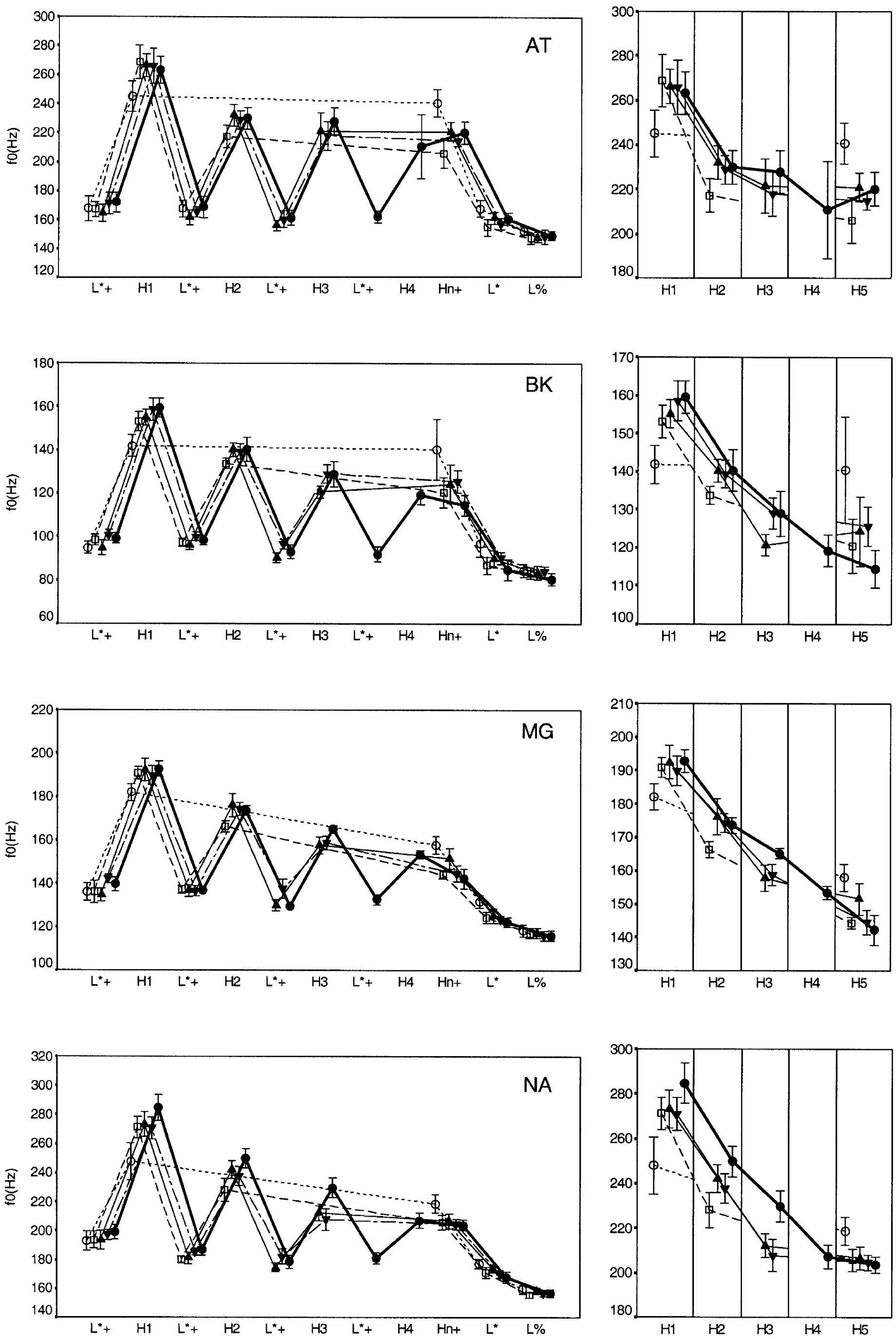

Fig. 5. The one-clause condition for the speakers with a final plateau and speaker CB with a final L*. Points in the plots represent means of nominally 12 measurements in Hz. Vertical bars show 95% confidence intervals for the means. Prenuclear rises are plotted at points (L* +)H1 … (L* +)H4. The H values of the nuclear fall are plotted at point Hn. L values are omitted in the plots on the right.

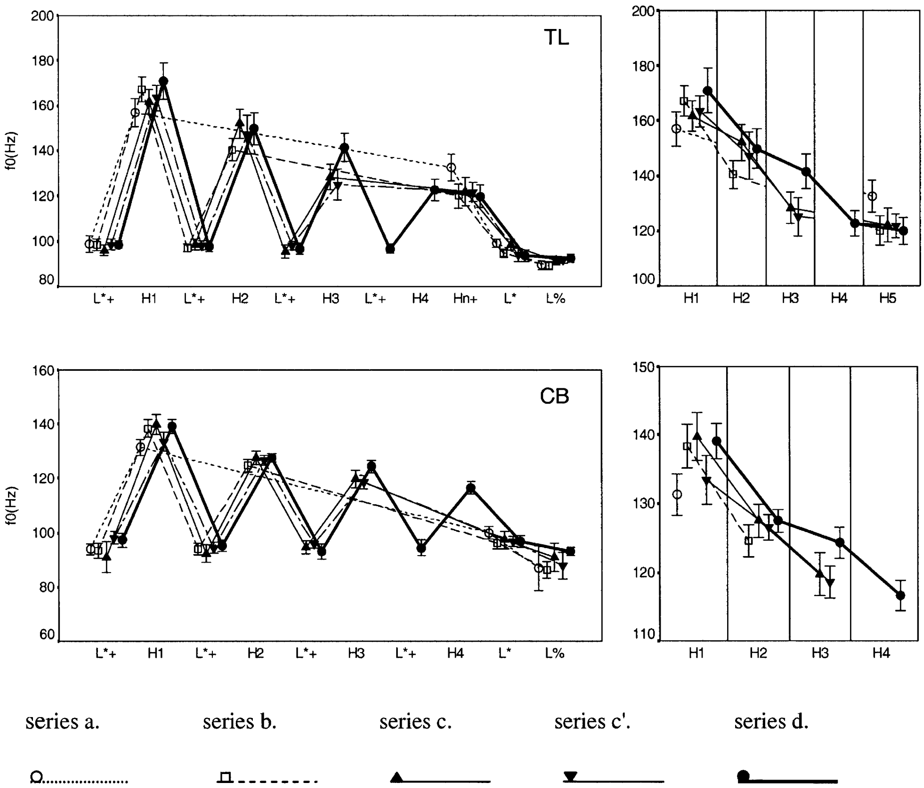

Fig. 5 (*continued*).

prenuclear rises for all speakers. Further, there are reasons to believe that there is no systematic effect of downstep within the final plateau, i.e., between the penultimate L + H rise and the final H + L fall. The absence of downstep in the final plateau is empirically supported in the longer series c., c′., and d. in Fig. 5 (and Fig. 6 below) where the plateau is by and large horizontal across speakers (exceptions are CB, due to the different final pitch accent, and MG, with a regularly falling plateau, which is here treated as speaker-specific).

If this interpretation is correct, the tonal pattern $L^* + H$ $H + L^*$ provides a test case for assessing whether final lowering will apply in non-final position if the chain of downstep ends before the nuclear accent. This test case extends to speaker CB for whom the final sequence is analyzed as $L^* + H$ L^*. Here, as with a final plateau, the $L^* + H$ rise in penultimate position is not followed by a downstepped H tone of a further pitch accent. The question of final lowering in penultimate position is assessed in Fig. 6, which shows pooled normalized values of prenuclear H tones of speakers AT, BK, CB, MG, NA, and TL (i.e., the speakers plotted in Fig. 5). The individual measurement values were here subject to the linear transformation:

$$\text{transformed\_value} = (\text{original\_value} - \text{Av}_s(\text{H}_3))/(\text{Av}_s(\text{H}_1) - \text{Av}_s(\text{H}_3)),$$

where $\text{Av}_s(T)$ is the speaker-specific mean of tone T (in the one-clause condition). The transformation thus rescaled for each speaker separately the mean of the H_1 measurements to 1

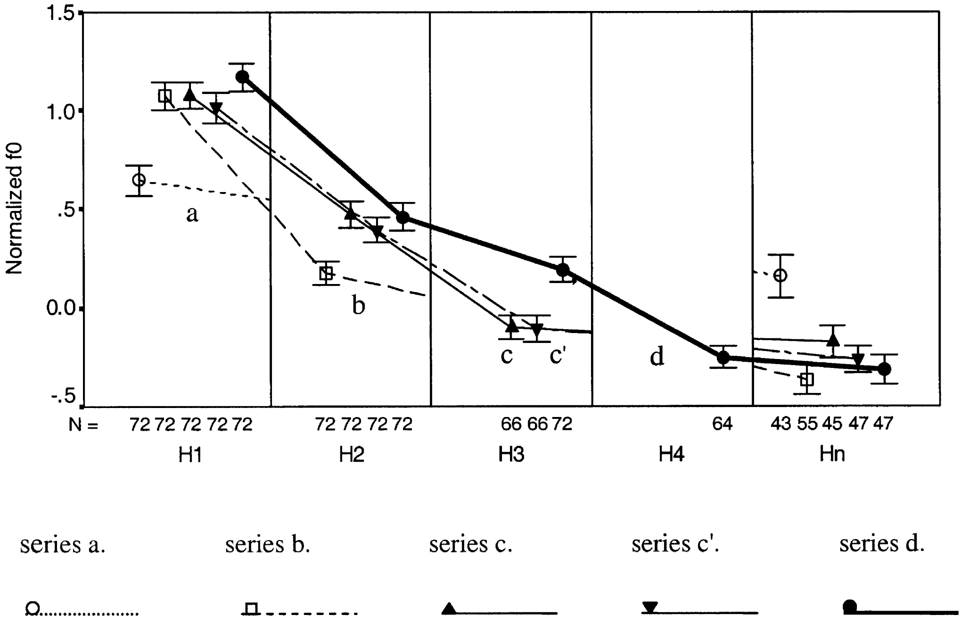

Fig. 6. Penultimate lowering preceding a non-downstepped nuclear pitch accent in the one-clause condition. 95% confidence-intervals are shown for the means of the pooled normalized values of speakers AT, BK, CB, MG, NA, and TL. N is the number of transformed measurements underlying each point out of nominally 72 (4 stimuli $\times$ 3 readings $\times$ 6 speakers).

and the mean of the H_3 measurements to 0. This transformation was chosen so as to factor out as far as possible both speaker-specific f_0 range and speaker-specific lowering by downstep.

An effect of final lowering in penultimate position is quite evident here. For one thing, it can be seen in the course of series (d), where the penultimate value at H_4 is lower than would be expected in continuation of earlier exponential decay in series (d) (compare the illustration in Fig. 1). It can also be inferred in series (c,c′) because, contrary to expectations, the curve does not become more shallow towards H_3. A 'vertical' comparison' also shows the effect of final lowering very clearly (see also Liberman & Pierrehumbert, 1984): Given downstep alone, one would expect all values plotted at the same point of the x-axis to be of indistinguishable height, for they have undergone the same number of steps of downstep (0 steps at H_1, 1 step at H_2, etc.). However a value that is penultimate in one series is generally lower than the values of other series plotted at the same point of the x-axis. Thus, at point H_1, series (a) has a lower value than series (b), (c), (c′), and (d). At point H_2, series (b) has a lower value than series (c), (c′), and (d). Likewise at point H_3, where series (c) and (c′) have lower values than series (d).

This result is strengthened by the pairwise comparison of values at the same point of the x-axis in Table 1. (Bonferroni adjustment is made by dividing the significance level 0.05 by the number of tests, 19. The Levene statistic shows that there is no significant deviation from identity of variance in the values compared.)

All t-tests of this vertical assessment that compare penultimate values with prepenultimate values indicate significant distinctions, while none of the t-tests comparing prepenultimate values

Table 1
Pairwise comparison of values at the same position, for the normalized pooled values of the one-clause condition of speakers AT, BK, CB, MG, NA, and TL (i.e. the values underlying Fig. 6)

t-Test	H1	H2	H3	Summary
Penultimate/Prepenultimate	a/b: $p<0.001$ a/c: $p<0.001$ a/c': $p<0.001$ a/d: $p<0.001$	b/c: $p<0.001$ b/c': $p<0.001$ b/d: $p<0.001$	c/d: $p<0.001$ c'/d: $p<0.001$	All significant ($p<0.05/19$)
Prepenultimate/ Prepenultimate (and Penultimate/ Penultimate in the case of c/c' at H3)	b/c: *ns* b/c': *ns* b/d: *ns* c/c': *ns* c/d: *ns* c'/d: $p=0.004$	c/c': *ns* c/d: *ns* c'/d: *ns*	c/c': *ns*	None significant ($p>0.05/19$)
Subgroups	[a] [b,c,c',d]	[b] [c,c',d]	[c,c'] [d]	

The results of two-tailed *t*-tests are evaluated relative to a significance level after Bonferroni adjustment ($p<0.05/19$). *ns* indicates $p>0.05$.

among each other reach statistical significance. The significant distinctions are evidence for final lowering in penultimate position, which also predicts the absence of such distinctions among prepenultimate values. Fig. 5 suggests that all speakers also show an effect of final lowering in penultimate position individually, with some variation across speakers.

Speaker FS has a final nuclear rise in the one-clause condition. The rise shares the characteristics of prenuclear L^*+H rises. Averaged measurements are shown in Fig. 7.

The plot of H tones on the right in Fig. 7 shows a pattern of downstep and dramatic final lowering among H tones that resembles particularly closely those reported in Liberman and Pierrehumbert (1984) and Prieto et al. (1996). Final lowering is evidenced in the final fall of the longer series c., c′ (position H_4) and d. (position 5). Final lowering is also clear in the vertical comparison, where the values that are final in each series are dramatically lower than the other values plotted at the same point of the *x*-axis (series a. at H_2, series b. at H_3, series c./c′ at H_4).

The data of FS does not directly bear on the question of interest here: In the most straightforward interpretation of the data of FS, a sequence of L^*+H rises is chained by downstep that extends to the final L^*+H rise. The tonal configuration of speaker FS, then, does not provide a test-case for final lowering in penultimate position.

Final lowering in final position for speaker FS seems to be more dramatic than final lowering in penultimate position for the other speakers evaluated here. This is addressed in the discussion section.

In summary, the speakers with an f_0-pattern analyzed as L^*+H … $H+L^*$ (or L^*+H … L^* for CB) show a clear effect of lowering in penultimate position on the last L^*+H pitch accent preceding the nondownstepped $H+L^*$ (or L^* for speaker CB). Speaker FS shows a clear effect of final lowering in utterance-final position on sequences of downstepped rises analyzed as L^*+H … L^*+H.

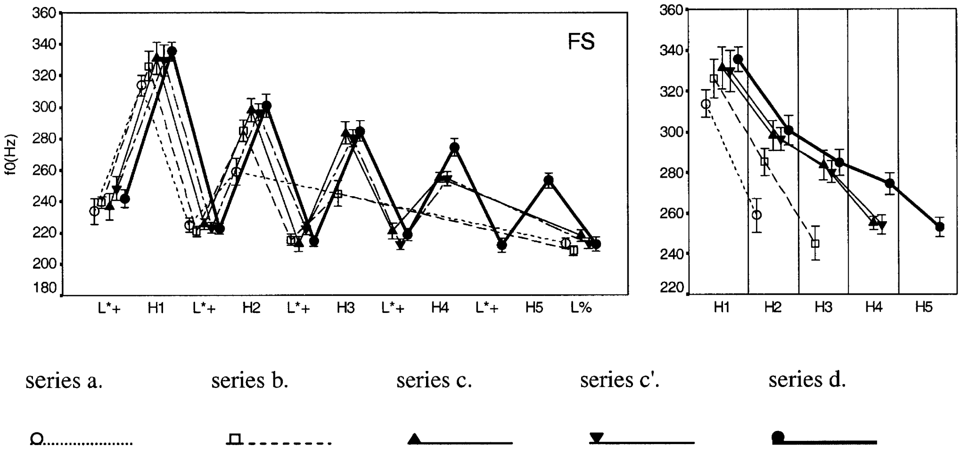

Fig. 7. One-clause condition for speaker FS. Points in the plots represent means of nominally 12 measurements in Hz. Vertical bars show 95% confidence intervals for the means.

3.2. Final lowering in non-final position in the two-clause condition

In the two-clause condition, final lowering in non-final position is assessed preceding clause-final upstep for speakers CB, MG, SW, and TL, who regularly produce clause-final upstep at the end of the first of two clauses (Truckenbrodt (2002); see Truckenbrodt (2001) for discussion of the medial clause-final pattern used by the remaining speakers). Plots for the first clause of the two-clause condition for these speakers are shown in Fig. 8. In the plots on the left, the upstepped values are plotted in sequence with the preceding values (upstep occurs at H_2 for series a., at H_3 for series b., at H_4 for series c., and at H_5 for series d.). These same upstepped values are plotted separately at point H_n in the plots on the right. The plots clearly show the effect of downstep among prenuclear pitch accents, and upstep on the nuclear pitch accent.

Fig. 9 assesses final lowering in position preceding upstep with a comparison of pooled normalized values for these four speakers, omitting the upstepped values themselves. Here, as in Fig. 6, the normalization employed a linear transformation that rescaled for each speaker the mean of H_1 measurements to 1 and the mean of H_3 measurements to 0. Here, as in the one-clause condition, a clear effect of final lowering in penultimate position is evident. It can be seen in the course of series (c) and (d) in that the expected effect of the curve becoming more shallow towards H_3 in series (c) and towards H_4 in series (d) is absent. The effect is also evident in the vertical comparison. In position H_1, series (a) is lower than the other series (b.-d.); in position H_2, series (b) is lower than series (c., d.); in position H_3, series (c) is lower than series (d). A pairwise comparison of the relevant values by *t*-tests is shown in Table 2.

All differences between penultimate values and prepenultimate values are significant, while the prepenultimate values are not significantly different from each other. The individual plots in the right panel of Fig. 8 show that the speakers also exhibited final lowering preceding upstep individually. Thus, the speakers who show upstep in the two-clause condition show a significant

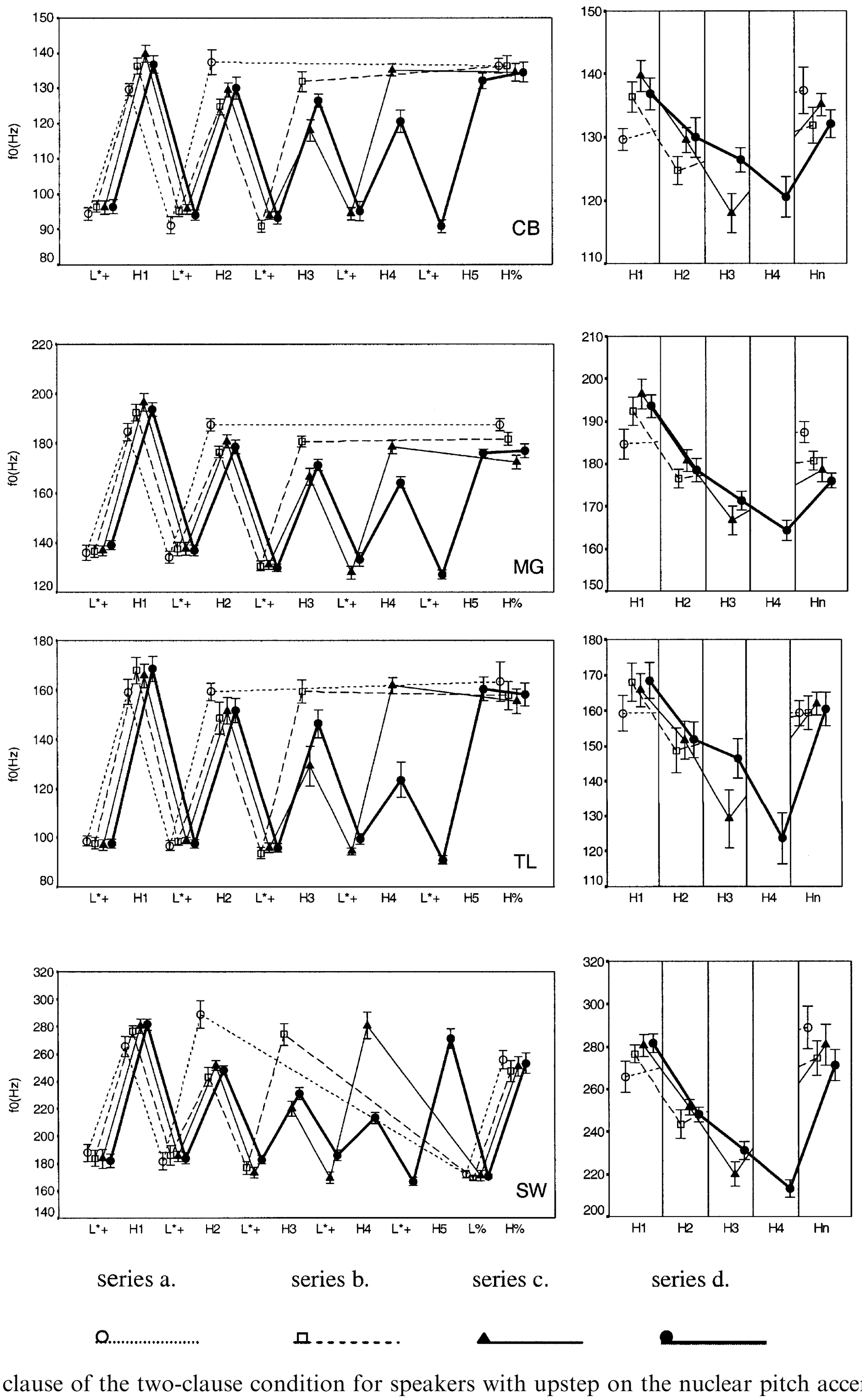

Fig. 8. The first clause of the two-clause condition for speakers with upstep on the nuclear pitch accent. Points in the plots represent means of nominally 18 measurements in Hz. Vertical bars show 95% confidence intervals for the means. In the plots on the left, the nuclear upstepped rise is plotted in continuation of the preceding downstepped rises. In the plots on the right, omitting L values, the nuclear upstepped rise is plotted separately at point H_n for all series.

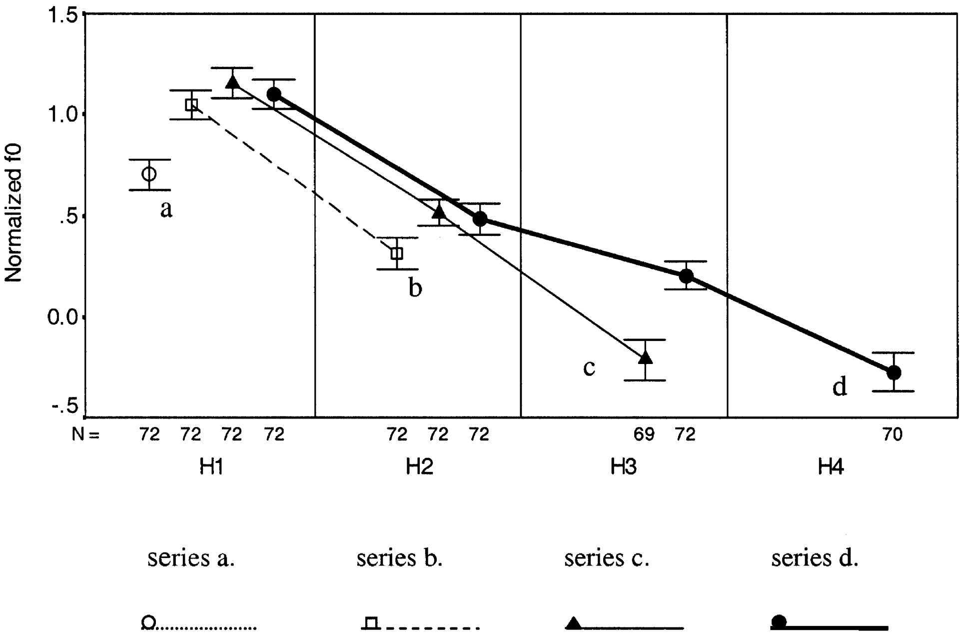

Fig. 9. Penultimate Lowering preceding upstep in the first clause of the two-clause condition. 95% confidence intervals are shown for the means of the pooled normalized values of speakers CB, MG, SW, and TL. *N* is the number of transformed measurements underlying each point out of nominally 72 (6 stimuli × 3 readings × 4 speakers).

Table 2
Pairwise comparison of the normalized pooled values of the two-clause condition of speakers CB, MG, SW, and TL (i.e. the values underlying Fig. 9)

t-Tests	H1	H2	H3	Summary
Penultimate/Prepenultimate	a/b: $p<0.001$ a/c: $p<0.001$ a/d: $p<0.001$	b/c: $p<0.001$ b/d: $p=0.002$	c/d: $p<0.001$	All significant ($p<0.05/10$)
Prepenultimate/ Prepenultimate	b/c: $p=0.043$ b/d: *ns* c/d: *ns*	c/d: *ns*		None significant ($p>0.05/10$)
Subgroups	[a] [b,c,d]	[b] [c,d]	[c] [d]	

The results of two-tailed *t*-tests are evaluated relative to a significance level after Bonferroni adjustment ($p<0.05/10$). *ns* indicates $p>0.05$.

effect of final lowering on the penultimate peak, immediately preceding the upstepped nuclear L* + ˆH.

For completeness, temporally faithful plots for the averaged measurements of both conditions are given in Fig. 10. Here the averaged values are plotted against their averaged temporal distance

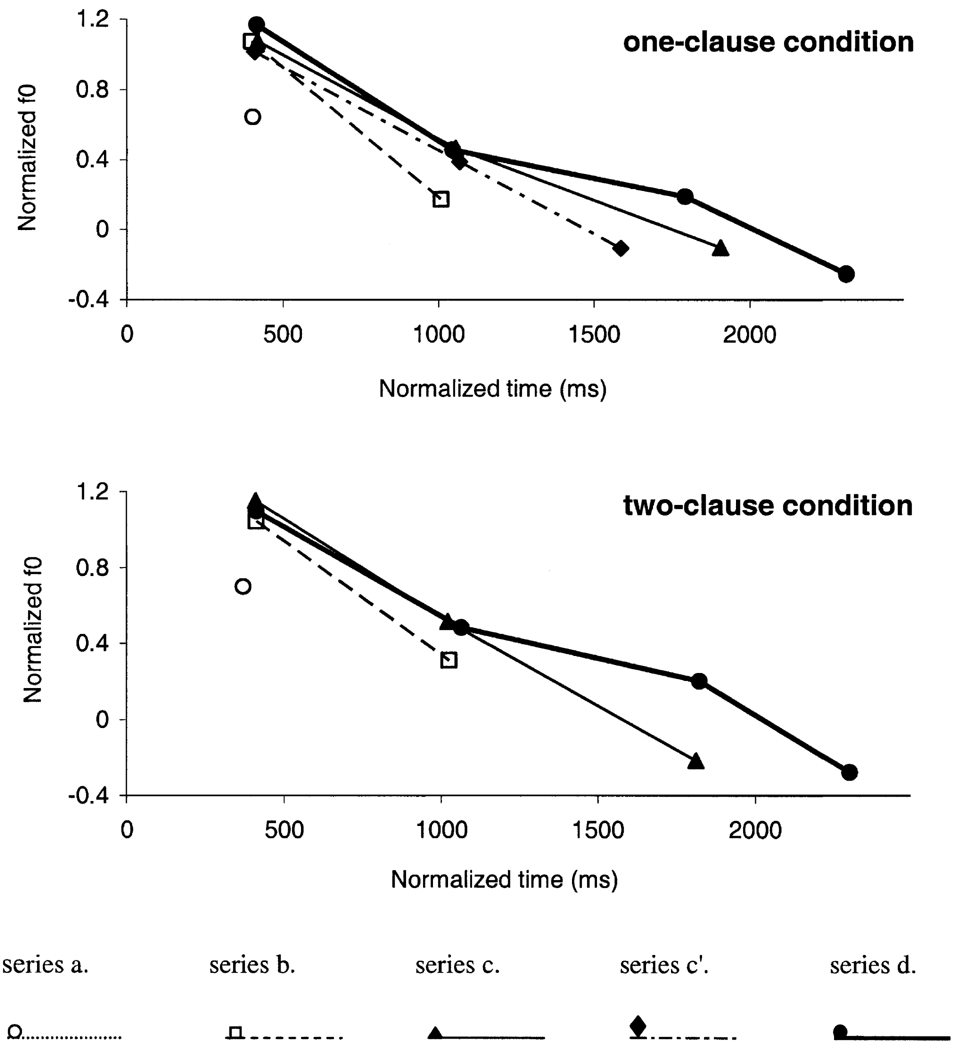

Fig. 10. Temporally faithful plots of the prenuclear measurements. Inclusion of speakers and normalization of f_0-values are as in Figs. 6 and 9. The temporal values used in the plots are means across the speakers of temporal distance from the utterance-beginning.

from the utterance-beginning. These plots are relevant for the discussion below in excluding declination as an alternative source of what is here attributed to final lowering.

4. Discussion

Sections 4.1–4.3 provide support for the interpretation of the results as final lowering in penultimate position. Arguments are provided against a number of alternative interpretations.

Section 4.4 offers an account of the results. Section 4.5 introduces a hypothesis about the nature of downstep that may lead to a more general understanding of the results.

4.1. Final lowering or declination?

This section assesses whether the effects analyzed as final lowering in non-final position can be attributed to declination. Grabe (1998) shows with sequences of downstepping $H^* + L$ accents in English that declination can affect the course of downstep. Her stimuli are lists of alternatingly short and long compounds with a constant first element. A compound is short if its second element is monosyllabic; a compound is long if its second element is bi- or trisyllabic. One set of lists begins the alternation with a long compound (**Moon**lighting, **moon**lit, **moon** landing, **moon**beam, **moon**flower), the other set of lists with a short compound (**Moon**lit, **moon**lighting, **moon**beam, **moon** landing, **moon**struck). The comparison of the two sets of lists showed a clear effect of length on the strength of downstep, with longer distance between accents leading to more lowering. (As mentioned, Prieto et al. (1996) did not find a comparable effect of declination on the course of downstep in their experiment on Mexican Spanish. The source of the difference between these finding remains unresolved here.)

When the expected effect of declination is calculated for downstep sequences of different length as investigated here, declination leads to a predicted patterning of the values similar in some respects to those expected under final lowering. Fig. 11 shows an idealized calculation for four series based on downstep and strong declination. Declination is calculated as proposed by Pierrehumbert (1980), with the total amount of declination constant across utterances. The dashed lines show the four baselines for the four series of different length. Very strong declination is assumed in these calculations, to bring out the effect it may have as clearly as possible. The solid lines show the predicted values for four series of downstep, if overlaid with declination based on

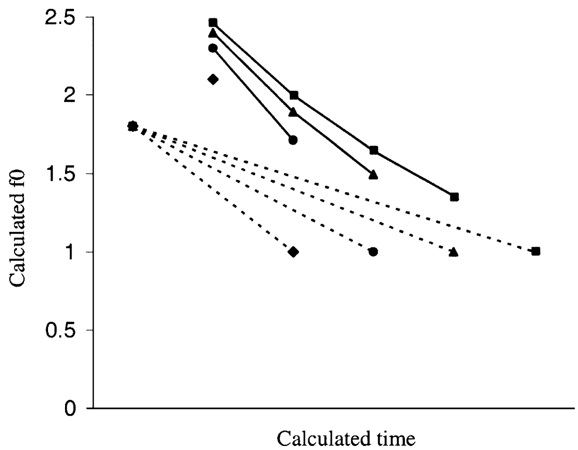

Fig. 11. Illustration of the prediction of downstep overlaid with strong declination for four series of different length. The dashed lines show the baselines that are used to calculate declination for each series. These baselines have identical initial and final height, but differ in duration. The predicted values can be seen above the baselines, and are connected by solid lines. Identical plotting symbols are used for each predicted series and its corresponding baseline (for example squares are used to plot the longest series and its baseline).

these baselines. The overlay was calculated by plotting all values in terms of multiples of the baseline above the baseline. (The calculations for this figure further assumed a constant absolute temporal distance *d* from the beginning of the utterance to the first accent in each series, from each accent to the next, and from the last accent to the end of the utterance.)

It can be seen that the vertical comparison of values here also shows a lower final value in comparison with non-final values of other sequences at the same point of the *x*-axis.

Magnitude estimates based on the amount of declination found in Pierrehumbert (1980) would not allow this effect to attain nearly the strength required to account for the effects of final lowering in Figs. 6 and 9. However, the effects reported in Grabe (1998) seem to be stronger, and so magnitude estimates cannot exclude this possible account of the findings in this article.

There are, however, a number of other ways in which the predictions of declination and those of final lowering can be contrasted. They suggest that the strongest effect is one of final lowering in the German data.

First, in Figs. 6 and 9, the longest sets (d) have a final leg towards H_4 that undergoes a stronger fall than the preceding leg of the same sequences. (In the normalized values of (d) in the one-clause condition, the fall of the leg towards H_4 is 0.44 and the preceding fall is 0.27. In the normalized values of (d) in the two-clause condition, the fall of the leg towards H_4 is 0.48 and the preceding fall is 0.28.) The only way in which this could be attributed to declination is if the final leg had a longer temporal duration than the preceding leg, in which case it could absorb a greater fraction of the overall declination. However, as Fig. 10 shows, the legs towards H_4 of the sequences (d) are actually shorter in duration than the preceding legs of these series, in both one- and two-clause condition. The more dramatic fall of the legs towards H_4 of the sequences (d) therefore cannot be attributed to declination, and is clear evidence of final lowering in penultimate position (H_4 in series (d)) in these sequences.

A second comparison between the predictions of final lowering and declination concerns the vertical comparisons. The prediction of declination seen in Fig. 11 is that the series 'drift apart' gradually. In the vertical comparison of values, this means that the values at the same point of the *x*-axis are expected to spread out along the vertical dimension as in Fig. 11. On the other hand, the prediction of final lowering is that the vertical separation among the series is limited to the position of final lowering, such that the vertical comparison distinguishes only values under final lowering from other values. Re-inspection of the values in positions H_1 and H_2 in Figs. 6 and 9 shows that there is no convincing effect of 'drifting apart' that affects values other than those in postulated final lowering.

A third argument to the same effect turns on the correctness of the conclusions of Truckenbrodt (2002). There I argue that the nuclear upstep in the two-clause condition of the same experiment abstractly targets the same height as the initial peak. The comparison between initial peak and upstepped peak allows declination in the two-clause condition to be estimated. As reported in Truckenbrodt (2002), speakers SW and CB showed no evidence of declination here. Yet these two speakers show clear effects of final lowering in penultimate position of the two-clause condition in Fig. 8. They also show clear effects of final lowering in penultimate position of the one-clause condition in Fig. 5. If these two speakers did not have declination during the experiment, their effects of final lowering cannot be reanalyzed as declination. Speaker TL furthermore, seemed to show some amount of declination between the initial peak and the upstepped peak (Truckenbrodt, 2002). However, magnitude estimates for speaker TL show that the amount of declination evidenced in the height of the upstepped peak is far too small to account for the effects of final lowering in penultimate position in the two-clause condition or in the one-clause condition. (The data of MG allowed no conclusion in this regard due to the incomplete execution of the upstep by this speaker; see Truckenbrodt (2002) for discussion.)

Altogether, these observations strongly suggest that the effects that are interpreted in terms of final lowering in penultimate position cannot instead be attributed to declination.

4.2. Final lowering or effects of syntactic structure?

In both one- and two-clause conditions, the stimuli of series (a) had no initial subject coordination in their syntactic structure, while the stimuli of series (b)–(d) use an initial constituent of subject coordination. There is, therefore, the possibility that the difference in position H_1 between series (a) on the one hand and series (b), (c), and (d) on the other is not due to final lowering as maintained earlier, but due instead to this syntactic difference. A hypothesis by Ladd and Johnson (1987) would in fact lead one to expect such a difference, though their own findings are not conclusive in this regard. On the other hand, van den Berg et al. (1992), following up on earlier discussion by Pierrehumbert and Beckman (1988), maintain for their Dutch data that phrase-internally, "H^*Ls are downstepped regardless of the configuration of the constituents in which they appear" (p.345).

The possible effect of initial subject coordination on the course of downstep can be assessed in the present experiment in the minimal comparison of series (c) and (c') in the one-clause condition. As described in Section 2.1, (c) shares the structure of initial subject coordination with (b) and (d), while (c′) is like (a) in lacking initial subject coordination. It can be seen in Fig. 6 and Table 1 that series (c) and (c′) are not significantly different from each other in positions H_1, H_2 or H_3. This supports the contention of van den Berg et al. (1992) that syntactic configurations do not affect phrase-internal downstep. Further, if the distinct height in position H_1 were due to the different syntactic structures, position H_1 in Table 1 should have shown the subgroups [a,c′] (with no initial subject coordination) vs. [b,c,d] (with initial subject coordination). This is not the case. By contrast, the interpretation of the difference in H_1 in terms of final lowering in penultimate position correctly predicts the groupings of [a] (H_1 in penultimate position) vs. [b,c,c′,d] (H_1 in earlier than penultimate position).

4.3. The tonal analysis and the prosodic analysis

This section clarifies two theoretical assumptions underlying the tonal and prosodic analysis of the experimental material, as relevant to the claim of final lowering in penultimate position.

The first of these is the absence of downstep in the final sequence L^*+H $H+L^*$. This contrasts with the downstepping behavior or prenuclear sequences L^*+H L^*+H as well as with the application of downstep in the final sequence L^*+H L^*+H of speaker FS in the one-clause condition. Empirical support for the absence of downstep in the final plateau was seen in Section 3.1. The absence of downstep in L^*+H $H+L^*$ is to be expected from cross-linguistic considerations. In many, though not all, languages, the presence of an L tone between H tones is a necessary condition for downstep (Odden, 1995). For Yorùbá, this has been experimentally established in some detail by Connell and Ladd (1990) and Laniran (1992). If the presence of an L tone is also a necessary condition for downstep in the German data discussed here, the different behavior of the different pitch accent sequences follows. Thus, in a sequence of two rises (L^*+H L^*+H ...) the two H tones are separated by L, and the second H tone is correspondingly downstepped. On the other hand, in the final plateau (L^*+H $H+L^*$) the two H tones in question are not separated by L, and consequently no downstep seems to occur. The absence of downstep within L^*+H $H+L^*$ thus makes sense on cross-linguistic grounds. (For a different analysis of English, see Beckman and Pierrehumbert (1986); these authors suggest that adjacent bitonal pitch accents undergo downstep in English regardless of the presence of an intervening L.)

The second issue addressed in this section is the prosodic analysis of the two-clause condition. It is important that the position analyzed as penultimate here is not instead domain-final. Thus, one might consider an analysis of the clause-final upstep as a domain-initial reset in prosodic terms. In such an analysis final lowering on the peak preceding upstep would not be penultimate but final in such a prosodic domain. Two analyses of this kind are considered here.

First, assume that the division between the two clauses is preserved in the division among intonation phrases *I*, as above, but that an additional smaller prosodic domain (say, the intermediate phrase of Beckman and Pierrehumbert (1986); here: *ip*) separates the upstepped peak from the preceding peaks. (In the following illustration, the material in the first syntactic clause is highlighted by underlining.)

```
[                                    ][          ]I
(                )(                  )(          )ip
(L*+H)(L* +! H)(L* +! H)(L* + ^H)(L*+H′)...
```

In this alternative analysis, upstep could be seen as a consequence of the *ip*-break to its left. Final lowering in the position preceding upstep would then be domain-final in the first *ip*, rather than penultimate in a larger domain. This analysis is rejected primarily on the grounds that it does not lead to an account of the height of the upstepped peak ($L^*+{}^\wedge H$) relative to the height of the first peak of the second clause (L^*+H'). In the structure considered here, these are both initial in an ip, and so should both show the effects of a domain-initial reset. Further, a height distinction between them is expected by which H' is higher than ${}^\wedge H$, since H' follows a larger boundary than ${}^\wedge H$. This expectation is based on the comparison of multiple resets in Ladd (1988, 1990), where a relatively larger boundary leads to a relatively higher reset after the boundary. In the German materials, however, the opposite is the case. ${}^\wedge H$ is considerably higher than H'. As shown in Truckenbrodt (2002), ${}^\wedge H$ is higher than H' by a height distinction approximately like that between utterance-initial and utterance-second peak (see the schematic illustration of peak height in Fig. 12 below). Therefore, the upstep phenomenon does not motivate a structure of the kind considered in this paragraph. A further problem for such an additional internal *ip*-division is that it is not accompanied by any of the characteristics that are expected of prosodic constituents. It does not define a position for frequent pauses (which are as infrequent in position immediately preceding upstep as in any earlier position); it does not define a stress-domain (the accented syllable preceding upstep is not perceived as more prominent than the preceding accented syllables); and it is not signaled by the presence of additional edge tones (again, the position preceding upstep and earlier positions are alike here). The structure under consideration is thus rejected since it does not lead to an account of upstep and since it leads to expectations about prosodic cues for a boundary that are not borne out.

Another possible interpretation of these data is that the main prosodic division (here *I*) does not coincide with the clause-boundaries (material in the first clause is again underlined here), but precedes the upstepped peak. This may (or may not) be accompanied by smaller *ip*-divisions that could still separate the two syntactic clauses.

```
[                                          ][                              ]I
(                                          )(             )(               )ip
(L*+H)(L* +! H)(L* +! H)(L* + ^H)(L*+H′)...
```

Given this structure, a plausible account of the scaling of ˆH and H′ seems possible. However, there are a number of indications in the experimental materials of the two-clause condition that the strongest internal prosodic boundary in this case coincides with the clause-boundary. First, all four speakers with upstep showed either frequent (CB) or quite regular (MG, TL, SW) long breath-pauses between the two clauses (whereas breath-pauses in the positions preceding upstep and elsewhere are rare). Second, the internal boundary that coincides with the clauses is marked by a sequence of two preceding edge tones for speakers SW and FS while all other internal divisions show evidence for at most one edge tone. Third, the first clause is plausibly a prosodic constituent since it serves as a stress-domain in which nuclear stress is assigned on the upstepped peak (by contrast, the strongest medial stress would wrongly be assigned in the position preceding upstep in the structure considered here). The structure considered here is rejected because the boundary strength asymmetry it predicts cannot be reconciled with the evidence that the strongest internal prosodic boundary is between the two clauses. This conclusion is compatible with native-speaker intuitions. There is a consistent intuition by native speakers that there is only one plausible way of dividing such utterances into two parts—at the point between the two clauses. The clause-final upstep is generally not felt to be the beginning of something new, but a device to signal the continuation after the end of the clause.

The analysis defended in Truckenbrodt (2002) is schematically illustrated in Fig. 12. The syntactic structure is mapped to a prosodic structure with one intonation phrase for the first clause and a separate intonation phrase for the second clause. This is compatible with the evidence for a prosodic boundary between the clauses, and is further in accord with cross-linguistic generalizations about intonation phrase formation (Nespor & Vogel, 1986). In the account of tonal scaling, the phrasal reference-line of van den Berg et al. (1992) is adopted. It is downstepped at the (intonation) phrase boundary. According to these authors, implementing ideas of Ladd (1988, 1990), downstep then proceeds away from the phrasal reference-line within each (intonation) phrase. In this model, Truckenbrodt (2002) analyzed the German upstep as a return to the phrasal reference-line at the end of the first intonation phrase, as shown in Fig. 12. According to this suggestion, upstep is like a reset in being a return to the phrasal reference-line, but unlike a reset in occurring in domain-final position. This account provides a link between the observed prosodic division and the scaling relation between ˆH and H′. Thus H′ (partial reset) returns to the phrasal reference-line at the beginning of a new domain, after the phrasal reference-line is lowered. By contrast, ˆH (upstep) returns to the phrasal reference-line at the end of the old domain, before the phrasal reference-line is lowered. The account then correctly predicts that ˆH

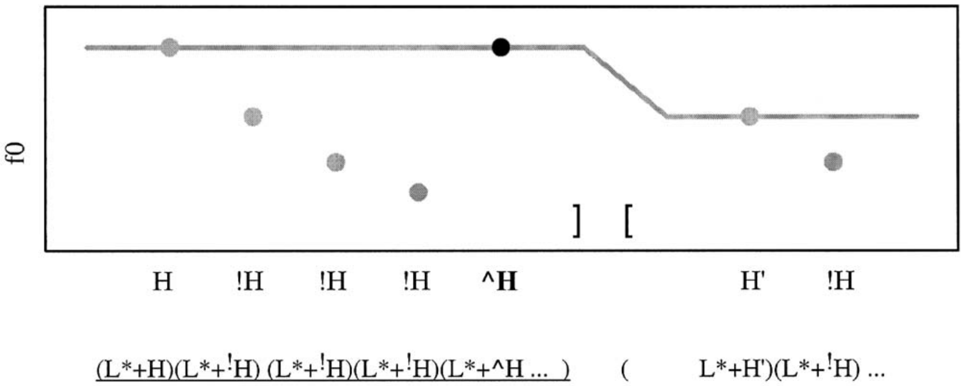

Fig. 12. Schematic illustration of the analysis of upstep. Elements in the first syntactic clause are underlined. Round brackets are accent domains, square brackets are intonation phrases. In the phonetic part of the illustration, only the values of H tones of the L^*+H pitch accents are shown. Gray parts reflect properties of the model of van den Berg et al. (1992): the downstepping phrasal reference-line, as well as the downstepping accents (gray dots) in each clause. The black dot shows the scaling of upstep relative to this model that was argued for in Truckenbrodt (2002).

is of comparable in height to the utterance-initial peak, and that it is separated from the following H′ by the lowering of the reference-line between the two intonation phrases. See Truckenbrodt (2002) for further discussion.

In summary, the upstep phenomenon provides no evidence for a larger prosodic boundary preceding upstep. Further, postulating a smaller internal boundary preceding upstep not only fails to account for upstep but also faces the problem of the absence of expected consequences of such an additional internal division. This suggests that there is no prosodic division that separates the upstepped pitch accent from the preceding material. The site of final lowering in the two-clause condition therefore seems to be in penultimate position of the intonation phrase, but not in final position of a comparable domain.

4.4. Final lowering in terms of raising before downstep

The data show significant effects of final lowering in what is arguably penultimate position. It was seen that this occurs preceding the nondownstepped nuclear pitch accent $H+L^*$ in the one-clause condition, and preceding the upstepped medial $L^*+\hat{}H$ in the two-clause condition. The position of final lowering is underlined here:

one-clause condition: [L^*+H $L^*+{}^!H$ … $L^*+{}^!\underline{H}$ $H+L^*$ L%]
two-clause condition: [L^*+H $L^*+{}^!H$ … $L^*+{}^!\underline{H}$ $L^*+\hat{}H$ H%][…]

Final lowering is here arguably conditioned by the distribution of downstep, and not by other factors of the phonological or phonetic environment. The two-clause condition shows that this effect of final lowering cannot be attributed to the influence of a following L% boundary tone: For three of the four speakers showing this pattern, the first intonation phrase of the two-clause condition does not terminate in an L% boundary tone, but with a H% that delimits a high plateau in continuation of the upstepped rise (see Truckenbrodt (2001) and the plots on the left in Fig. 8). These speakers individually show the effect of final lowering. (The fourth speaker participating in the upstep pattern of the two-clause condition, SW, has a combination of LH% boundary tones.) Further, in both one- and two-clause condition, it seems that final lowering cannot be triggered by phrase-final (or utterance-final) position. Both occurrences of final lowering are on the penultimate pitch accent of a larger intonational domain. A further possibility of reducing the observed phenomenon to final lowering in final position is also rejected here. By that hypothesis, final lowering would apply in final position with some carry-over to penultimate position. Small amounts of such carry-over to penultimate position have been postulated by Prieto et al. (1996) for their data. Such an account requires that there is a primary effect of final lowering in final position that is stronger than the postulated carry-over effect in penultimate position. This is the case in the Mexican Spanish data of Prieto et al. (1996), where a dramatic primary effect of final lowering in final position is the source of the postulated carry-over to penultimate position. Applied to the two-clause condition of the German data, one would then look for the primary effect of final lowering in the position of the upstepped peak. It is clear that the phonetic values here are not literally lower than those in penultimate position. Therefore this hypothesis, applied to the German data, makes sense only on an abstract conception of final lowering in which final lowering affects, in some sense, the entire tonal space, and thus lowers all values in it. One would then expect the primary effect of final lowering in final position to reduce the upstepped peak at least as strongly as the postulated carry-over effect in penultimate position reduces the expected height of that peak. However, the upstepped peaks are on average as high as the initial peaks for speakers SW and CB, who show penultimate lowering preceding upstep. If upstep is scaled to the phrasal reference-line, as argued in Truckenbrodt (2002), then the actual height of the upstepped peak for these speakers is evidence that there is no final lowering in final position (in the first clause of the two-clause condition). Therefore, there is no basis for the explanation of the effect in penultimate position in terms of carry-over. A similar case can be made for speaker TL. Though the upstepped peaks here are lower than the initial peak by a difference *d*, the effect of final lowering preceding upstep is larger than *d* in the longer series (c) and (d), so that an account in terms of clause-final lowering and carry-over does not seem tenable. (The effect cannot be assessed for speaker MG, due to his incomplete execution of the upstep; see Truckenbrodt (2002) for discussion. It is also difficult to assess this hypothesis in the one-clause condition; however, the horizontal nature of the plateaus for the longer series of most speakers also suggests that the effect of final lowering in penultimate position is not due to carry-over from final position).

Taken together, all this suggests that a factor distinguishes penultimate and prepenultimate values in both conditions that does not directly or indirectly stem from the upcoming end of the first intonation phrase. The only distinction left, then, that could trigger this effect is that the penultimate accent is not followed by further downstep, while earlier accents are followed by downstepped accents.

Notice then that there does not literally have to be a chain of downstepped elements for the effect to occur: Final lowering occurs in initial position H_1 (see Figs. 6 and 9 as well as Tables 1 and 2). Here the initial L^*+H_1 of series (a), followed by nondownstepping $H+L^*$ or $L^*+{}^\wedge H$, shows a significantly lower peak than initial L^*+H_1 in series (b)–(d) and (c′), where it is followed by downstepping $L^* + {}^!H_2$. The position of final lowering is again underlined here:

series a.: $[L^* + \underline{H}_1\ L^* + \hat{}H][\ldots]$ series b.-d., c′.: $[L^* + H_1\ L^* + {}^!H_2 \ldots][\ldots]$
$[L^* + \underline{H}_1\ H + L^*]$ $[L^* + H_1\ L^* + {}^!H_2 \ldots]$

The formulation that seems to best generalize across this and the other instances of final lowering is that *values not followed by downstep are lower than values followed by downstep*, *all else being equal*. One may seek to capture this effect in a rule of Raising before Downstep. Such a rule would amplify the height of target T (above a reference-line) by a factor m in position preceding downstep:

Raising before downstep

$T \rightarrow mT/\_!$ where $m > 1$.

By this rule, all values followed by downstepping $L^* + {}^!H$ are raised, while values followed by non-downstepping $H + L^*$ and $L^* + \hat{}H$ are not raised. An effect of final lowering then results indirectly: positions not affected by raising before downstep (i.e., those not followed by downstep) come out lower than those affected by raising before downstep (i.e., those followed by downstep). In initial position, then, the first peak of series (a) is not raised, not being followed by downstep, while the first peaks in the other series are raised, since they are followed by downstep. The same applies in other positions, where the vertical comparisons show that values not followed by downstep (in penultimate position) are lower than values followed by downstep (in prepenultimate position). The effect of raising before downstep on a longer sequence of downstepped pitch accents is schematically shown in Fig. 13. The rule of raising before downstep is to be thought of as superimposed on the calculation of downstep as exponential decay. In a sequence $H_1!H_2 \ldots !H_{n-1}!H_n$, the non-final elements $H_1 \ldots H_{n-1}$ are each followed by downstep, and are thus raised by raising before downstep. Assuming a constant factor m of raising before

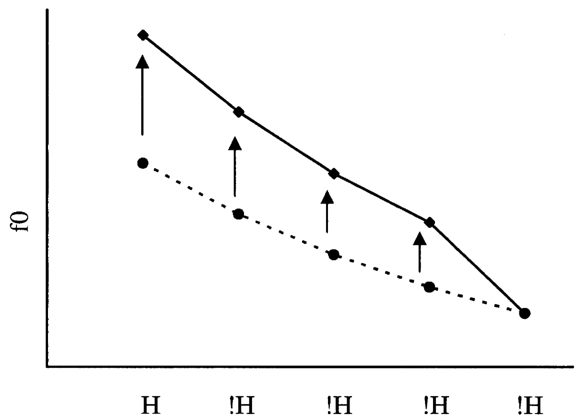

Fig. 13. Schematic illustration of the analysis of final lowering in terms of raising before downstep. Dashed lines represent the course of downstep as it would be without raising before downstep, solid lines represent the predicted course of downstep with the inclusion of raising before downstep.

downstep, the exponentially decaying shape among these non-final tones is preserved under the raising process. The final element H_n, however, is not followed by downstep, and thus not subject to raising before downstep. It would then be lower than if it were scaled in regular continuation of the preceding course of raised values.

Raising before downstep correctly predicts the occurrence of final lowering in penultimate position of the intonation phrase as in the experiment reported here, where the penultimate pitch accent is not followed by downstep on the nuclear accent. Raising before downstep can also predict the occurrence of final lowering in utterance-final position in Liberman and Pierrehumbert (1984), Laniran (1992), and Prieto et al. (1996), or may at least contribute to final lowering in final position. In connection with the Yorùbá experiments of Laniran (1992) that include a medial reset, raising before downstep also leads to the expectation of final lowering in a position immediately preceding a medial reset. Laniran (1992) investigates this possibility (see pp. 205–213; see also the plots on pp. 193–196), with no clear conclusion. Her evaluation rests on a comparison between the amount of f_0-lowering preceding the medial reset and the amount of f_0-lowering in utterance-final position. A different picture emerges from the inspection of the medial sequences … H_{n-2}L!H_{n-1}L!H_n *L reset*-H_{n+1} … where H_n is the last tone preceding a partial reset. In 17 out of 18 sentence-patterns (across two speakers) in which two downstepped H tones precede a clear medial reset, f_0-lowering is more dramatic between H_{n-1} and H_n than between H_{n-2} and H_{n-1} (see (e)–(h) on pp. 209f and 212f; see also pp. 193–196 in Laniran, 1992). Against an expectation of exponentially decaying downstep (which is otherwise plausible for Laniran's data), this is a clear indication of some amount of final lowering preceding a medial reset in Laniran's data. However, as Laniran's comparison with final lowering in final position suggests, such medial occurrences of final lowering may be less dramatic than final lowering in final position.

There is an indication of such a difference between final lowering in final position and final lowering in non-final position in the German data evaluated here as well. As noted, the effect of final lowering in final position for FS (Fig. 7) seems to be more dramatic than the effect of final lowering in penultimate position for the other speakers (Figs. 5, 6, 8, and 9).

If one attributes final lowering in medial position to raising before downstep, there is then an indication that raising before downstep is only one among a number of factors contributing to final lowering in final position.

If the scaling of a tone depends on whether or not it is followed by downstep, the relevant rules of scaling (here: raising before downstep) must be granted a certain amount of look-ahead. Pierrehumbert (1980) and Liberman and Pierrehumbert (1984) did not find the need to allow preplanning in their data. Final lowering, it seems, could be the kind of phenomenon that requires look-ahead, such as look-ahead to a following larger prosodic boundary, or to a later boundary tone. However, in Liberman and Pierrehumbert (1984 pp. 192f, 219) it was pointed out that there are different possible ways to understand final lowering. Some of these possibilities (such as resulting from pulmonary control) may exempt final lowering from the phenomena that would be accounted for by rules that assign phonetic values to phonological elements. The component of final lowering isolated here, however, seems to require look-ahead as to the presence or absence of following downstep by the rules of scaling. As mentioned in the introduction, Pierrehumbert and Beckman (1988) attribute final lowering in their Japanese data to a right-to-left effect emanating from a final boundary tone. Pierrehumbert and Beckman (1988) suggest an analysis of this effect that obeys a prosodic locality provision. Rules of scaling for an element X are allowed to 'look upward' from X in the prosodic tree, and to take into account properties of dominating prosodic nodes. The relevant boundary tones are properties of such higher nodes in their theory, so that the boundary tones are allowed to affect the scaling of earlier tones inside of these higher nodes. The sensitivity to following downstep does not naturally fall within this notion of locality. If a pitch accent is an element pertaining to the accentual phrase, the scaling within one accentual phrase here seems to require information about the following accentual phrase. Pierrehumbert and Beckman (1988, p. 162) find it conceivable that there are rules of scaling that refer to the following phonological context and provide candidate examples from the literature. To these, one may add the later findings of Laniran (1992) and Xu (1997). Whether the sensitivity of scaling to following downstep, as argued for here, is an instance of phonological or phonetic look-ahead will remain open in this article. It is at least possible to construe it as phonological look-ahead. For example, if, as argued by Ladd (1983a) and van den Berg et al. (1992), downstep is represented as a phonological feature, such look-ahead is trivially phonological in nature. Other ways of reducing this to phonological look-ahead also seem to exist. On the other hand, if the hypothesis outlined in the following section should turn out to be correct, then the effect under consideration would be part of a systematic instance of phonetic look-ahead.

4.5. Downstep and raising before downstep

Why would there be a rule of raising before downstep? It seems possible that downstep itself and raising before downstep are two sides of the same coin. The underlying factor might be that of giving prominence to an element X by strengthening its phonetic realization *relative to the phonetic realization of following elements*. The target of the unifying factor would thus be increased phonetic distance between the phonetic realization of X and the phonetic realization of following elements. Downstep contributes to this by reducing the phonetic realization of following elements. Raising before downstep contributes to this by increasing the phonetic realization of the prominent element itself.

These considerations are to a certain extent consistent with findings of Xu (1999) for Mandarin Chinese. Xu (1999) studied the influence of focus on the course of f_0 in Mandarin Chinese in sentences of the form subject-verb-object. Utterances with no narrow focus provided the background for the observations on focus. Focus on either the subject or the verb had two phonetic consequences for the range of f_0 in Xu's (1999) study: The element in focus had an expanded f_0-range, while the elements following the focus were realized in a f_0-range that was lowered and compressed. In this case, then, it may be said that focus (rather than accents) expresses its prominence by raising its own f_0 range and lowering and compressing the following f_0 range. There is also an indication in Xu's data that these two effects are tied to each other to some extent. Xu observed that focus on the final object (where there was no following material to be realized in a lowered and compressed f_0 range) showed a considerably reduced effect of raising in the focus itself. This suggests that the raising in the focus was at least to some extent directly tied to the lowering after the focus.

Further suggestive support for such a view may be seen in the intonation system of Tokyo Japanese (McCawley, 1968; Poser, 1984; Pierrehumbert & Beckman, 1988). Here downstep is triggered by the accentual tones HL, of which H associates with the accented mora. In the assessment of Poser (1984) and Pierrehumbert and Beckman (1988), downstep takes effect with the L tone of the accent. One may thus notate it as $H^{!}L$. In contrast to the accentual tones, the 'phrasal H' tone (Pierrehumbert & Beckman, 1988) does not trigger downstep, even if it is separated from the next H tone by a L tone. A further difference between accentual H and 'phrasal' H is that the accentual H tone is scaled somewhat higher than the 'phrasal' H, all else being equal. On the view offered here, one may see the additional height of the accentual H and the immediately following downstep as two sides of the same coin, tied to each other and both being part of a way of giving prominence to the accented mora. This would tie together two distinctions between the accentual H and the 'phrasal' H tone that are otherwise accounted for separately.

5. Summary

The German data investigated here show an effect of 'final lowering' in penultimate position, preceding non-downstepped nuclear pitch-accents. These instances of final lowering can arguably not be attributed to a rule that induces final lowering due to triggers in the phonological environment, such as a following phrase-boundary or a following L% boundary tone. Instead, it appears that a factor of final lowering is that values followed by downstep are realized higher than values not followed by downstep, all else being equal. An implementation of this effect by a rule of raising before downstep is proposed. The rule applies regardless of other elements of the phonological environment, and raises elements followed by downstep. This derives the correct natural class of 'final' elements as those that are not followed by downstep, and thus not raised by this rule. The data allow for the possibility that raising before downstep is one among a number of factors contributing to final lowering in utterance-final position.

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Appendix. The stimuli

In the transcriptions of the stimuli, accented syllables are underlined, accent domains are indicated by round brackets, and intonation phrases are indicated by square brackets.

One-clause condition

a1. Die Lola will das Nähen lernen. '*Lola wants to learn sewing.*'
[(dɪ ˈloːla) (vɪl das ˈnɛːən ˈlɛɐ̯nən)]

a2. Die Hanne soll Bananen essen. '*Hanne is supposed to eat bananas.*'
[(dɪ ˈhanə) (zɔl baˈnaːnən ˈɛsn̩)]

a3. Der Maler will Nonnen malen. '*The painter wants to paint nuns.*'
[(dɛɐ̯ ˈmaːlɐ) (vɪl ˈnɔnən ˈma:lən)]

a4. Der Maurer will das Weben lernen. '*The painter wants to learn weaving.*'
[(dɛɐ̯ ˈmaʊʁɐ) (vɪl das ˈveːbm̩ ˈlɛɐ̯nən)]

b1. Der Werner und die Lola wollen malen lernen. '*Werner and Lola want to learn to paint.*'
[(dɛɐ̯ ˈvɛɐ̯nɐ) (ʊnt dɪ ˈloːla) (ˈvɔlən ˈmaːlən ˈlɛɐ̯nən)]

b2. Der Lehrer und der Maurer wollen nähen lernen. '*The teacher and the painter want to learn to sew.*' [(dɛɐ̯ ˈleːʁɐ) (ʊnt dɛɐ̯ ˈmaʊʁɐ) (ˈvɔlən ˈnɛːən ˈlɛɐ̯nən)]

b3. Die Nonne und der Lehrer wollen malen lernen. "*The nun and the teacher want to learn to paint.*' [(dɪ ˈnɔnə) (ʊnt dɛɐ̯ ˈleːʁɐ) (ˈvɔlən ˈmaːlən ˈlɛɐ̯nən)]

b4. Die Lena und die Manu wollen die Nonne malen. '*Lena and Manu want to paint the nun.*'
[(dɪ ˈleːna) (ʊnt dɪ ˈmaːnu) (ˈvɔlən dɪ ˈnɔnə ˈma:lən)]

c1. Ein Tiger und ein Löwe wollen einem Lama Maronen wegnehmen.
'*A tiger and a lion want to take away sweet chestnuts from a llama.*'
[(aɪ̯n ˈtiːgɐ) (ʊnt aɪ̯n ˈlø:və) (ˈvɔlən ˈaɪ̯nəm ˈlaːma) (maˈʁoːnən ˈvɛkˌneːmən)]

c2. Die Lena und die Hanne wollen einem Maurer das Weben beibringen.
'*Lena and Hanne want to teach weaving to a bricklayer.*'
[(dɪ ˈleːna) (ʊnt dɪ ˈhanə) (vɔlən ˈaɪ̯nəm ˈmaʊʁɐ) (das ˈveːbm̩ ˈbaɪ̯bʁɪŋən)]

c3. Der Maler und der Lehrer wollen der Hanne Maronen geben.
'*The painter and the teacher want to give sweet chestnuts to Hanne.*'
[(dɛɐ̯ ˈmaːlɐ) (ʊnt dɛɐ̯ ˈleːʁɐ) (ˈvɔlən dɛɐ̯ ˈhanə) (maˈʁoːnən ˈgeːbm̩)]

c4. Der Werner und die Lena wollen dem Lehrling Manieren beibringen.
'*Werner and Lena want to teach manners to the apprentice.*'
[(dɛɐ̯ ˈvɛɐ̯nɐ) (ʊnt dɪ ˈleːna) (ˈvɔlən dem ˈleːɐ̯lɪŋ) (maˈniːɐ̯n ˈbaɪ̯bʁɪŋən)]

c'1. Die Nonne will der Lola in Murnau eine Warnung geben. '*The nun wants to give Lola a warning in Murnau.*' [(dɪ ˈnɔnə) (vɪl dɛɐ̯ ˈloːla) (ɪn ˈmʊ ɐ̯naʊ) (aɪ̯nə ˈvaɐ̯nʊŋ ˈge:bm̩)]

c'2 Die Lola will der Lena im November Maronen geben. '*Lola wants to give sweet chestnuts to Lena in November.*' [(dɪ ˈloːla) (vɪl dɛɐ̯ ˈleːna) (ɪm noˈvɛmbɐ) (maˈʁoːnən ˈge:bm̩)]

c'3 Die Lena will dem Werner im Januar ein Lama malen. '*Lena wants to paint a llama for Werner in January.*' [(dɪ ˈleːna) (vɪl dem ˈvɛɐ̯nɐ) (ɪm ˈjanu̯aːɐ̯) (aɪ̯n ˈlaːma ˈma:lən)]

c'4. Die Manu soll der Lena im Januar das Leinen weben. '*Manu is supposed to weave the linen for Lena in January.*' [(dɪ ˈmaːnu) (zɔl dɛɐ̯ ˈleːna) (ɪm ˈjanu̯aːɐ̯) (das ˈlaɪ̯nən ˈveːbm̩)]

d1. Die Nonne und der Lehrer wollen der Lola in Murnau eine Warnung geben.
'*The nun and the teacher want to give Lola a warning in Murnau.*'
[(dɪ ˈnɔnə) (ʊnt dɛɐ̯ ˈleːʁɐ) (ˈvɔlən dɛɐ̯ ˈloːla) (ɪn ˈmʊ ɐ̯naʊ) (aɪ̯nə ˈvaɐ̯nʊŋ ˈgeːbm̩)]

d2. Die Lola und die Manu wollen der Lena im November Maronen geben.
'*Lola and Manu want to give sweet chestnuts to Lena in November.*'
[(dɪ ˈloːla) (ʊnt dɪ ˈmaːnu) (ˈvɔlən dɛɐ̯ ˈleːna) (ɪm noˈvɛmbɐ) (maˈʁoːnən ˈgeːbm̩)]

d3. Die Lena und die Lola wollen dem Werner im Januar ein Lama malen.
'*Lena and Lola want to paint a llama for Werner in January.*'
[(dɪ ˈleːna) (ʊnt dɪ ˈloːla) (ˈvɔlən dem ˈvɛɐ̯nɐ) (ɪm ˈjanu̯aːɐ̯) (aɪ̯n ˈlaːma ˈmaːlən)]

d4. Die Manu und die Hanne sollen der Lena im Januar das Leinen weben.
'*Manu and Hanne are supposed to weave the linen for Lena in January.*'
[(dɪ ˈmaːnu) (ʊnt dɪ ˈhanə) (zɔln dɛɐ̯ ˈleːna) (ɪm ˈjanu̯aːɐ̯) (das ˈlaɪ̯nən ˈveːbm̩)]

Two-clause condition

Only the first clause of the two-clause condition is relevant for the measurements reported in this article, and transcribed here. For al.-a4., bl.-b4., cl.-c4., and dl.-d4., the first clause of the two-clause condition is identical to the (only) clause of the one-clause condition, transcribed above. A repetition of the transcriptions is omitted here for reasons of space.

a1. Die Lola will das Nähen lernen, und die Manu und die Lena sollen ihr eine Nähmaschine kaufen. '*Lola wants to learn sewing, and Manu and Lena are supposed to buy a sewing machine for her.*'

a2. Die Hanne soll Bananen essen, und die Lena und der Werner sollen ihr welche mitbringen. '*Hanne is supposed to eat bananas, and Lena and Werner are supposed to bring her some.*'

a3. Der Maler will Nonnen malen, und die Lena und die Hanne sollen ihm Modell stehen. '*The painter wants to paint nuns, and Lena and Hanne are supposed to sit for him.*'

a4. Der Maurer will das Weben lernen, und die Hanne soll ihm Leinen und Wolle besorgen. '*The painter wants to learn weaving, and Hanne is supposed to get linen and wool for him.*'

a5. Die Lena will eine Malve malen, und im Januar will der Werner nach Hamburg gehen.
'*Lena wants to paint a mallow, and Werner wants to go to Hamburg in January.*'
[(dɪ ˈleːna) (vɪl ˈaɪ̯nə ˈmalvə ˈmaːlən)] […]

a6. Der Werner soll Rommé lernen, und der Rommélehrer soll aus Lüneburg oder aus Hamburg kommen. '*Werner is supposed to learn rummy, and the rummy teacher is supposed to come from Lüneburg or from Hamburg.*' [(dɛɐ̯ ˈvɛɐ̯nɐ) (zɔl ˈʁɔme ˈlɛɐ̯nən)] […]

b1. Der Werner und die Lola wollen malen lernen, und die Manu will dem Lehrer Rommé zeigen.'*Werner and Lola want to learn to paint, and Manu wants to show rummy to the teacher.*'

b2. Der Lehrer und der Maurer wollen nähen lernen, und die Nonne will dem Heiner Wolle leihen. '*The teacher and the painter want to learn to sew, and the nun wants to lend wool to Heiner.*'

b3. Die Nonne und der Lehrer wollen malen lernen, und die Lena will dem Werner einen Roman geben. ‘*The nun and the teacher want to learn to paint, and Lena wants to give a novel to Werner.*’

b4. Die Lena und die Manu wollen die Nonne malen, und der Werner soll in Murnau einen Roman schreiben. ‘*Lena and Manu want to paint the nun, and Werner is supposed to write a novel in Murnau.*’

b5. Der Lehrer und die Hanne wollen nähen lernen, und der Maler und die Lena wollen nach Hamburg ziehen. ‘*The teacher and Hanne want to learn to sew, and the painter and Lena want to move to Hamburg.*’ [(dɛɐ̯ ˈleːʁɐ) (ʊnt dɪ ˈhanə) (ˈvɔlən ˈnɛːən ˈlɛɐ̯nən)] […]

b6. Der Wladimir und die Hanne wollen ein Lama malen, und die Lola soll der Lena Wolle leihen. ‘*Wladimir and Hanne want to paint a llama, and Lola is supposed to lend wool to Lena.*’ [(dɛɐ̯ ˈvlaːdiˌmiːɐ̯) (ʊnt dɪ ˈhanə) (ˈvɔlən aɪ̯n ˈlaːma ˈmaːlən)] […]

c1. Ein Tiger und ein Löwe wollen einem Lama Maronen wegnehmen, und ein Marabu und eine Möwe wollen einen Wurm fangen. ‘*A tiger and a lion want to take away sweet chestnuts from a llama, and a marabou and a seagull want to catch a worm.*’

c2. Die Lena und die Hanne wollen einem Maurer das Weben beibringen, und der Manuel will die Lola in Murnau besuchen. ‘*Lena and Hanne want to teach weaving to a bricklayer, and Manuel wants to visit Lola in Murnau.*’

c3. Der Maler und der Lehrer wollen der Hanne Maronen geben, und der Maurer will der Lena Murnau zeigen. ‘*The painter and the teacher want to give sweet chestnuts to Hanne, and the bricklayer wants to show Lena Murnau.*’

c4. Der Werner und die Lena wollen dem Lehrling Manieren beibringen, und die Lola will dem Manuel eine Warnung geben. ‘*Werner and Lena want to teach manners to the apprentice, and Lola wants to give Manuel a warning.*’

c5. Der Werner und die Lena wollen der Nonne ein Lama malen, und der Heiner will in Hamburg eine Mole mauern. ‘*Werner and Lena want to paint a llama for the nun, and Heiner wants to build a jetty in Hamburg.*’ [(dɛɐ̯ ˈvɛɐ̯nɐ) (ʊnt dɪ ˈleːna) (ˈvɔlən dɛɐ̯ ˈnɔnə) (aɪ̯n ˈlaːma ˈmaːlən)] […]

c6. Der Maurer und die Nonne wollen dem Lehrer Malvenrum bringen, und der Werner will der Manu einen Roman vorlesen. ‘*The bricklayer and the nun want to bring the teacher mallow-rum, and Werner wants to read a novel to Manu.*’ [(dɛɐ̯ ˈmaʊʁɐ) (ʊnt dɪ ˈnɔnə) (ˈvɔlən dem ˈleːʁɐ) (ˈmalvənˌʁʊm ˈbʁɪŋən)] […]

d1. Die Nonne und der Lehrer wollen der Lola in Murnau eine Warnung geben, und die Hanne will im November ein Lama malen. ‘*The nun and the teacher want to give Lola a warning in Murnau, and Hanne wants to paint a llama in November.*’

d2. Die Lola und die Manu wollen der Lena im November Maronen geben, und der Werner will der Hanne ihr Leinen weben. ‘*Lola and Manu want to give sweet chestnuts to Lena in November, and Werner wants to wave her linen for Hanne.*’

d3. Die Lena und die Lola wollen dem Werner im Januar ein Lama malen, und die Manu soll im November Bananen essen. ‘*Lena and Lola want to paint a llama for Werner in January, and Manu is supposed to eat bananas in November.*’

d4. Die Manu und die Hanne sollen der Lena im Januar das Leinen weben, und der Werner soll in Murnau Maronen holen. ‘*Manu and Hanne are supposed to weave the linen for Lena in January, and Werner is supposed to get sweet chestnuts in Murnau.*’

d5. Der Maler und der Lehrer wollen der Lena in Malmö einen Marabu geben, und die Lola will sich im Januar eine Wohnung nehmen. ‘*The painter and the teacher want to give Lena a marabou in Malmö, and Lola wants to take an apartment in January.*’ [(dɛɐ̯ ˈmaːlɐ) (ʊnt dɛɐ̯ ˈleːʁa) (ˈvɔlən dɛɐ̯ ˈleːna) (ɪn ˈmalmø) (ˈa̯ɪnən ˈmaʁabu ˈgeːbm̩)] […]

d6. Der Maurer und sein Lehrling wollen dem Werner in Kamerun ein Lama malen, und der Maler will im Januar in Murnau wohnen. ‘*The bricklayer and his apprentice want to paint a llama for Werner in Cameroon, and the painter wants to live in Murnau in January.*’ [(dɛɐ̯ ˈmaʊʁɐ) (ʊnt za̯ɪn ˈleːɐ̯lɪŋ) (ˈvɔlən dem ˈvɛɐ̯nɐ) (ɪn ˈkamɛʁʊn) (a̯ɪn ˈlaːma ˈmaːlən)] […]

Speaker SW read two-clause stimuli that were later made more uniform for recordings with the other speakers. The changes are minor and within the limits of the description of the two-clause condition in the text. As far as they concern the first clause, they are (i) the use of some longer accented words rather than the shorter ones used for the other speakers: (c2), (c3): ‘Hannelore’/‘Hanne’; (c4): ‘Maurerlehrling’/‘Lehrling’; (c6): ‘Rommélehrer’/‘Lehrer’; and (ii) the use of three sentences with the same syntactic structure but longer words, rather than three sentences with shorter words: (b4): ‘Kamerun und die Niederlande sollen Lehrermangel haben, und …’; (b5): ‘Der Rommélehrer und die Hannelore wollen in einer Lagerhalle wohnen, und …’; (b6): ‘Der Wladimir und die Hannelore wollen Mengenlehre lernen, und … .’ Further, SW used the dialectal ‘Jänner’ instead of ‘Januar’.

References

Atterer, M., & Ladd, D. R. (2004). On the phonetics and phonology of “segmental anchoring” of F0: Evidence from German. *Journal of Phonetics*, *32*(2), 177–197.

Barker, G. (2002). *Intonation patterns in Tyrolean German: An autosegmental-metrical analysis*. Doctoral dissertation, University of California, Berkeley.

Beckman, M. E., & Pierrehumbert, J. B. (1986). Intonational structure in Japanese and English. *Phonology Yearbook*, *3*, 255–309.

Bierwisch, M. (1966). Regeln für die Intonation deutscher Sätze. *Studia Grammatica*, *7*, 99–201.

Büring, D. (2001). What do definites do that indefinites definitively don’t? In C. Féry, & W. Sternefeld (Eds.), *Audiatur vox sapientiae. A Festschrift for Arnim von Stechow* (pp. 70–100). Berlin: Akademie Verlag.

Cinque, G. (1993). A null theory of phrase and compound stress. *Linguistic Inquiry*, *24*, 239–297.

Connell, B., & Ladd, D. R. (1990). Aspects of pitch realisation in Yoruba. *Phonology*, *7*, 1–29.

Féry, C. (1992). Focus, topic and intonation in German: Arbeitspapiere des Sonderforschungsbereichs 340, ‘Sprachtheoretische Grundlagen für die Computerlinguistik’, Bericht No. 20. Universität Tübingen.

Féry, C. (1993). *German intonational patterns*. Tübingen: Niemeyer.

Fitzpatrick-Cole, J. (1999). The Alpine intonation of Bern Swiss German. Paper presented at *International congress of phonetic sciences*, San Francisco (pp. 941–944).

Grabe, E. (1998). *Comparative intonational phonology: English and German*. Doctoral dissertation, Universiteit Nijmegen.

Grice, M., & Baumann, S. (2002). Deutsche Intonation und GToBI. *Linguistische Berichte*, *191*, 267–298.

Grice, M., Baumann, S., & Benzmüller, R. (in press). German intonation in autosegmental-metrical phonology. In S.-A. Jun (Ed.), *Prosodic typology. The phonology of intonation and phrasing*. Oxford: Oxford University Press.

Grice, M., Reyelt, M., Benzmüller, R., Mayer, J., & Batliner, A. (1996). Consistency in transcription and labelling of German intonation with GToBI. In M. Reyelt, & W. Idsardi (Eds.), *Proceedings of the fourth international conference on spoken language processing* (pp. 1716–1719). New York: Institute of Electrical and Electronic Engineers.

Gussenhoven, C. (1983). Focus, mode and the nucleus. *Journal of Linguistics*, *19*, 377–417.

Gussenhoven, C. (1992). Sentence accents and argument structure. In I. M. Roca (Ed.), *Thematic structure. Its role in grammar* (pp. 79–106). Berlin, New York: Foris.

Gussenhoven, C., & Rietveld, T. (1988). Fundamental frequency declination in Dutch: Testing three hypotheses. *Journal of Phonetics*, *16*, 355–369.

Herman, R. (1996). Final lowering in Kipare. *Phonology*, *13*, 171–196.

Höhle, T. N. (1982). Explikationen für "normale Betonung" und "normale Wortstellung". In W. Abraham (Ed.), *Satzglieder im Deutschen. Vorschläge zur syntaktischen, semantischen und pragmatischen Fundierung* (pp. 75–153). Tübingen: Narr.

Jacobs, J. (1993). Integration. In M. Reis (Ed.), *Wortstellung und lnformationsstruktur* (pp. 63–116). Tübingen: Niemeyer.

Jacobs, J. (1999). Informational autonomy. In P. Bosch, & R. van der Sandt (Eds.), *Focus. Linguistic, cognitive, and computational perspectives* (pp. 56–81). Cambridge: Cambridge University Press.

Kügler, F. The phonology and phonetics of rising pitch accents in Swabian. In P. Gilles, & J. Peters (Eds.), *Regional variation in intonation*. Tübingen: Niemeyer (to appear).

Ladd, D. R. (1983a). Phonological features of intonational peaks. *Language*, *59*, 721–759.

Ladd, D. R. (1983b). Even, focus, and normal stress. *Journal of Semantics*, *2*, 257–270.

Ladd, D. R. (1988). Declination 'reset' and the hierarchical organization of utterances. *Journal of the Acoustical Society of America*, *84*, 530–544.

Ladd, D. R. (1990). Metrical representation of pitch register. In J. Kingston, & M. Beckman (Eds.), *Papers in laboratory phonology I: Between the grammar and physics of speech* (pp. 35–57). Cambridge: Cambridge University Press.

Ladd, D. R., & Johnson, C. (1987). 'Metrical' factors in the scaling of sentence-initial accent peaks. *Phonetica*, *44*, 238–245.

Laniran, Y. (1992). *Intonation in tone languages: The phonetic implementation of tones in Yorùbá*. Doctoral dissertation, Cornell University.

Liberman, M., & Pierrehumbert, J. (1984). Intonational invariance under changes in pitch range and length. In M. Aronoff, & R. T. Oehrle (Eds.), *Language, sound, structure: Studies in phonology presented to Morris Halle by his teacher and students* (pp. 157–223). Cambridge, MA: MIT Press.

McCawley, J. D. (1968). *The phonological component of a grammar of Japanese*. The Hague: Mouton.

Nespor, M., & Vogel, I. (1986). *Prosodic phonology*. Dordrecht: Foris.

Odden, D. (1995). Tone: African languages. In J. Goldsmith (Ed.), *The handbook of phonological theory* (pp. 444–475). Cambridge, MA: Blackwell.

Peters, J. (2002). Intonation und Fokus im Hamburgischen. *Zeitschrift für Sprachwissenschaft*, *189*, 27–57.

Pheby, J. (1981). Phonologie: Intonation. In K. E. Heidolph, W. Flamig, & W. Motsch (Eds.), *Grundzüge einer deutschen Grammatik* (pp. 839–897). Berlin: Akademie-Verlag.

Pierrehumbert, J. B. (1980). *The phonology and phonetics of English intonation*. Doctoral dissertation, MIT.

Pierrehumbert, J. B., & Beckman, M. E. (1988). *Japanese tone structure*. Cambridge, MA: MIT Press.

Poser, W. J. (1984). *The phonetics and phonology of tone and intonation in Japanese*. Doctoral dissertation, MIT.

Prieto, P., Shih, C., & Nibert, H. (1996). Pitch downtrends in Spanish. *Journal of Phonetics*, *24*, 445–473.

Selkirk, E. (1984). *Phonology and syntax: The relation between sound and structure*. Cambridge, MA: MIT Press.

Selkirk, E. (1995). Sentence prosody: Intonation, stress, and phrasing. In J. Goldsmith (Ed.), *The handbook of phonological theory* (pp. 550–569). Cambridge, MA: Blackwell.

Shih, C. (2000). A declination model of Mandarin Chinese. In A. Botinis (Ed.), *Intonation. Analysis, modeling and technology*. Dordrecht: Kluwer.

Truckenbrodt, H. (2001). *On the scaling of high edge tones in German*. MS. Rutgers University.

Truckenbrodt, H. (2002). Upstep and embedded register levels. *Phonology*, *19*, 77–120.

Uhmann, S. (1991). *Fokusphonologie*. Tübingen: Niemeyer.
van den Berg, R., Gussenhoven, C., & Rietveld, T. (1992). Downstep in Dutch: Implications for a model. In G. J. Docherty, & D. R. Ladd (Eds.), *Papers in laboratory phonology II: Gesture, segment, prosody* (pp. 335–367). Cambridge: Cambridge University Press.
Xu, Y. (1997). Contextual tonal variations in Mandarin. *Journal of Phonetics*, *25*, 61–83.
Xu, Y. (1999). Effects of tone and focus on the formation and alignment of F0 contours. *Journal of Phonetics*, *27*, 55–105.
Zubizarreta, M. L. (1998). *Prosody, focus, and word order*. Cambridge, MA: MIT Press.