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The nature and use of Icelandic prenuclear and nuclear pitch accents: Evidence from F0 alignment and syllable/segment duration

Nicole Dehé

Two production studies and one perception study were designed to systematically test F0 alignment and segment duration in Icelandic pitch accents with a view to investigating previous claims about the inventory of distinct intonational categories. Four different conditions were tested: (i) prenuclear pitch accents, (ii) nuclear accents in sentence-final position in sentences with either broad focus or (iii) with final narrow focus, and (iv) nuclear narrow focus accents in non-final position. The alignment results are such that (i) prenuclear accents are signalled by a late rise (L*H), while final nuclear accents are signalled by an early rise; (ii) F0 peaks in prefinal nuclear accents are aligned earlier than in prenuclear accents, but later than in final nuclear accents, suggesting a prosodic boundary effect. The duration measurements suggest a positional, but no focus, effect on the duration of the accented syllable and its vowel, such that syllables/vowels earlier in the sentence are longer than later ones.

Keywords F0 alignment, focus, Icelandic, intonation, nuclear accent, prenuclear accent

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1. INTRODUCTION

The aim of this paper is to study Icelandic pitch accents in a systematic way, testing their tonal and temporal properties in four different environments with a view to investigating claims in the literature about the inventory of distinct intonational categories in Icelandic. Pitch accents in Icelandic are intonational and focus-marking. Haugen (1958:74) notes that '[i]n unemotional speech or reading, each primary accent is accompanied by a melodic rise above the speaker's average pitch' and that '[a]n extra-high pitch . . . is also heard as reinforcement of stress'. According to more recent work on Icelandic intonational phonology, Icelandic has two bitonal pitch accents (H*L and L*H; Árnason 1998a, Dehé 2009) and two monotonal pitch accents (H* and L*; Dehé 2009), with H*L being the most frequent one. The starred tone has been perceptually linked to the stressed syllable, while the trailing tone of bitonal pitch accents has been argued to be completed by the time the next vowel is reached, or more generally, by the end of the following syllable (Árnason 1998a). As a rule,

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Icelandic has word-initial primary stress (Árnason 1985, 1987, 1998a; Einarsson 1973; Thráinsson 1994; among others). The starred tone of a bitonal pitch accent is thus predicted to be associated with the first syllable of a word and the trailing tone is predicted to be completed by the end of the second syllable of the same word or any other immediately following (unstressed) syllable. This is illustrated for H*L in (1) (borrowed from Árnason 1998a:53), where the word *Dísa*, a proper noun, bears a nuclear H*L pitch accent. The local peak is associated with the first syllable *Dí-*; the following fall from the local peak is completed at the end of the syllable *-sa*.

(1) Þarna er Dísa komin.
H*L
there is Dísa arrived
'Dísa has arrived.'

The difference between Icelandic bitonal and monotonal pitch accents has thus been argued to be in the timing of the pitch movement after the starred tone, which occurs on the immediately adjacent syllable in bitonal, but not in monotonal accent types (Dehé 2009). However, the exact relation between tonal targets on the one hand and segmental material on the other hand has not yet been systematically studied. In particular, the alignment of the starred tone with the stressed syllable as well as the alignment of tonal landmarks leading to and following the starred tone has yet to be investigated. Moreover, the distinction between bitonal and monotonal pitch accents has to-date been based on phonetic evidence alone (Dehé 2009); a phonological contrast between them has not been established. Little is known about intonational meaning. Árnason (1998a) establishes a difference in meaning between high and low boundary tones (H% and L%, respectively), such that L% is used to mark finality, i.e. it is primarily used at the end of utterances, while H% signals non-finality. Accordingly, Árnason (1998a:53–56) describes H*L L% as a typical sequence at the end of declarative utterances, while L*H H% and H*L H% occur utterance-internally, i.e. at the end of an Intonational Phrase preceding another Intonational Phrase in the same utterance. L*H L% and L*H H% are used in *yes*/*no*-questions. Both H% and L% seem to terminate both *yes*/*no*- and *wh*-questions (Dehé 2009). As for pitch accents, all four observed pitch accent types may, in principle, occur in prenuclear and nuclear position, in declarative and interrogative sentences, in neutral utterances and for the marking of narrow focus (Dehé 2009; see also Dehé 2006 for focus-marking pitch accents). In nuclear position, H*L is the most frequently found pitch accent type. 'Short utterances are typically produced with a sequence of downstepped H*L pitch accents . . . or with one or more L*H pitch accents followed by one or more H*L accents' (Dehé 2009:14). What we know about Icelandic intonation is thus unsatisfactory. If the distribution of the observed accent types is identical or very similar, then there may be no evidence for the phonological reality of these pitch accents. In other words, it is possible that they are different phonetic manifestations

of the same phonological entity. This is particularly true for the difference between bitonal and monotonal accent types, whose occurrence has merely been observed without evidence for systematic variation between the two variants (Dehé 2009). Also, given the systematic distinction between prenuclear and nuclear accents identified for other languages (see below), it is highly likely that different categories can also be identified for Icelandic.

It is the aim of this paper to look more closely at the timing and distribution of Icelandic pitch accents. Two parameters will be considered: the alignment of F0 targets with segmental material, and the duration of the stressed syllable and its vowel segment. Focusing on prenuclear accents versus nuclear accents and on nuclear accents in sentences with broad focus and narrow focus, the following environments will be tested:

- prenuclear accents in a broad focus context
- non-final nuclear accents (narrow focus)
- sentence-final nuclear accents (broad focus)
- sentence-final nuclear accents (narrow focus)

Quite independently of theoretical frameworks, research in intonation has established 'that intonational distinctions can be conveyed by differences in the way pitch movements are aligned with the segmental string' (Ladd 2008:169; see Ladd 2008:169–188 for a survey). For example, F0 alignment in Neapolitan Italian nuclear LH rises distinguishes between *yes*/*no*-questions (late alignment; L*H) and statements (early alignment; LH*); see, for example, D'Imperio (2000). In many languages, prenuclear accent peaks are aligned later than nuclear accent peaks (e.g., Silverman & Pierrehumbert 1990 for English; Arvaniti & Baltazani 2005 for Greek; Schepman, Lickley & Ladd 2006 for Dutch). In prenuclear accents, the peak may be aligned in the syllable following the perceptually stressed one (e.g., Silverman & Pierrehumbert 1990 and Ladd, Faulkner, Faulkner & Schepman 1999 for English; Arvaniti, Ladd & Mennen 1998 for Greek; Ladd, Mennen & Schepman 2000 for Dutch; Atterer & Ladd 2004 for two varieties of German; Hellmuth 2006 for Egyptian Arabic). However, the alignment of tonal targets perceptually associated with prenuclear or nuclear accented syllables has been shown to be subject to various phonological and phonetic factors across languages, among them syllable type/structure, prosodic context, proximity and type of a following phrasal boundary, tonal crowding, prenuclear versus nuclear pitch accents, and speech rate. For example, the alignment of the prenuclear peak in Dutch within or after the stressed syllable is affected by the phonological length of the vowel in the stressed syllable: H is aligned before the offset of a long vowel, but in the next consonant if the vowel is short (Ladd et al. 2000). In Egyptian Arabic, H is outside open light (CV) stressed syllables, but just inside open heavy (CVV) and closed (CVC) stressed syllables (Hellmuth 2006). Prieto & Torreira (2007) find that H is aligned late in the vowel of an open stressed syllable, but within the coda consonant

in closed stressed syllables. Previous research has shown that peak alignment is earlier before a stronger prosodic boundary, e.g., at the end of an utterance or before an Intonational Phrase boundary, than before a weaker prosodic boundary such as the edge of an intermediate phrase (e.g., Silverman & Pierrehumbert 1990 for English; Prieto, van Santen & Hirschberg 1995 for Mexican Spanish). At discourse level, peak alignment is earlier in paragraph-final or sentence-final contexts than in paragraph-initial and sentence-initial contexts (Wichmann, House & Rietveld 2000). It has also been observed that the location of the F0 peak in falling accents varies according to whether the fall is linked to a neutral contour or a focus contour. For example, Frota (2002:392) illustrates for European Portuguese how the F0 peak precedes the stressed syllable in a neutral contour but coincides with the stressed syllable in a focus contour. According to Gili Fivela (2002), the tonal targets in Italian H*+L pitch accent types are aligned earlier in a contrastive focus context than in a broad focus context. Alignment and timing characteristics have also been used to decide between bitonal pitch accents on the one hand and a combination of monotonal pitch accent and edge tone on the other hand (e.g., Frota 2002 for European Portuguese; Ladd & Schepman 2003 for English). For example, for the low target preceding H* to qualify as part of a complex pitch accent, it should be in a strict relationship with H*, i.e., it should always be aligned with a certain segmental landmark preceding the one linked to the starred tone, irrespective of other factors.

In previous research, segment duration has been shown to be affected by emphasis. For example, Cooper, Eady & Mueller (1985) show for English that the duration of a target word is longer when it is focused than when it is not. Féry & Kügler (2008) obtain similar effects for German. At a segmental level, Arvaniti, Ladd & Mennen (2006) show for Greek that consonants and vowels of stressed syllables are longer in contrastive statements than in questions.

Against this background, research questions arising for Icelandic include the following:

(2) *Research questions*

(i) Is there evidence from F0 alignment for differences between pre-nuclear and nuclear accents, and between nuclear accents of different types and in different positions (e.g., broad focus/narrow focus, pre-final position/sentence-final position)?
(ii) Can supporting evidence be found for the accent types previously identified for Icelandic: H*L, L*H, H* and L*?
(iii) Based on the evidence from F0 alignment, can other accent types be identified?
(iv) Does syllable or segment lengthening serve as a clue to nuclear versus pre-nuclear accents or to broad versus narrow focus accents?

The remainder of the paper is organised as follows. Section 2 reports on two production studies designed to address the questions in (2). Section 3 reports on a perception study designed to specifically address the comparison between prenuclear accents and nuclear accents in the same non-final position. The overall results are discussed in section 4. Section 5 serves as a summary, conclusion and outlook.

2. PRODUCTION

The two reading studies reported on in this section were designed to produce data on the nature of Icelandic pitch accents occurring in different positions and serving different functions. Specifically, the alignment of pitch targets with the segmental string and the duration of prominent syllables and their segments were studied. Pitch accents in prenuclear position were compared with pitch accents in nuclear position, and pitch accents marking narrow focus were compared with nuclear pitch accents in sentences with broad focus. To this end, the alignment of tonal targets such as pitch peaks and flanking valleys were measured against segmental landmarks in stressed initial syllables in words of three or four syllables. The general methodology of the experiments was inspired by that employed in, for example, Atterer & Ladd (2004) and Hellmuth (2006: chapter 7). Naturally, some aspects of the design had to be adapted to the specific characteristics of the Icelandic language.

2.1 Experiment 1

2.1.1 Materials

Target syllables were selected according to the nature of the Icelandic vowel system and syllable structure. The vowel inventory of Modern Icelandic consists of the eight monophthongal vowels in (3a) and the five diphthongs in (3b), all of which 'according to standard analysis have long or short allophones depending on the environment' (Árnason 1998b:6).

(3) *Modern Icelandic vowel system* (from Árnason 2005:1561)

a. monophthongs: a [a], e [ɛ], i/y [ɪ], í/ý [i], o [ɔ], u [ʏ], ú [u], ö [œ]

b. diphthongs: á [au], ó [ou], æ [ai], ei/ey [ɛi], au [øy]

According to Árnason (1998b:6), the vowel length rule of thumb is such that 'a vowel is structurally short if it is in a closed syllable and structurally long if it is in an open syllable'.[1] Disregarding the details, 'the general view is that vowel length and syllabification go hand in hand but that the conditioning factor is the syllabification' (Árnason 1998b:7). While structurally long vowels (i.e., vowels in open syllables) are lengthened under stress, structurally short vowels (i.e., vowels in closed syllables) cannot be lengthened, and cannot carry a regular stress beat. Therefore, short vowels

take consonants as complements in the nucleus (Árnason 1998b). The lengthening of this final consonant under stress has traditionally been referred to as 'half length' (see Árnason 1998b:4; 2005:1563). Taken together, it follows that syllabification in words with more than one syllable is as in (4) below. A single consonant between two nuclei becomes the onset of the second syllable, resulting in an open first syllable with a long vowel (see (4a)). Two or more consonants between vowels are syllabified such that the first consonant closes the first syllable, while the second (and further) consonant(s) form the onset to the second syllable (see (4b)). The first syllable is closed and has a short vowel followed by a half-long consonant (indicated by [ˑ] in (4b).[2] Due to these properties of syllabic structure, all syllables with primary stress are heavy (Árnason 1980:96) and there are no open stressed syllables with short vowels in Modern Icelandic.

(4) *Syllabification in Modern Icelandic* (examples from Árnason 2005:1563)
a. CV e.g., the first syllable in *bera* [pɛˑ.ra] 'to carry'
b. CVC e.g., the first syllable in *hestur* [hɛsˑ.tʏr̥] 'horse'

In the present study, all target syllables were initial syllables of nouns. They were open heavy syllables (CVː) as in (4a) and closed heavy syllables (CVC) as in (4b). In order to exclude vowel quality as a factor possibly affecting F0 alignment, all vowels in target syllables were low or low-mid back vowels [a] and [ɔ]. To facilitate pitch tracking, the flanking consonants were all sonorants: the onset consonant was the voiced nasal /m/; the final consonant in closed syllables was the voiced nasal /n/ or the voiced trill /r/.[3] An open syllable was followed by a sonorant onset on the next syllable – the voiced lateral /l/.

According to Ladd (2008:96) and Beckman & Elam (1997:15f.), L+H*(L) and H*(L) may be difficult to distinguish on a phrase-initial syllable. Since Icelandic has word-initial primary stress, this is particularly important to take into account. All target nouns were therefore embedded in carrier sentences such that they were preceded by an unstressed mono-syllabic preposition in the same phrase. All nuclear accents were in sentence-final position (see (5) and (6) below), while prenuclear accents were in a position earlier in the sentence (see (7)).

To allow for comparison between nuclear and prenuclear pitch accents and between nuclear pitch accents in broad focus contexts and in narrow focus contexts, the three different contexts illustrated in (5)–(7) were chosen. In (5), the target noun was in final position to receive main prominence under neutral stress (broad focus); in (6), the target noun was in final position as in (5) but produced with narrow focus, where narrow focus was elicited by a preceding context-establishing question; in (7), the target noun was in a broad focus sentence in a position where it received a prenuclear pitch accent.[4] Each of these three conditions was represented by four target sentences. To control for a possible effect of syllable structure, two of the four target syllables in each condition were open (CVː) and two were closed (CVC). The target syllables were the open syllable *ma* [maː] in *Malasíu* and *malarú*, and the

closed syllables *mor* [mɔr] in *morgunmat* and *man* [man] in *mandarínum*. The target syllables (and nouns) were the same across the three contexts to allow for comparison of identical segmental strings. Overall, there was a total of 12 target items, which are given in (5)–(7), preceded by their respective item numbers (e001–e012). Target syllables are in bold face.

(5) *Target word with nuclear accent in final position; broad focus*

Open syllable: CV

e001 Icelandair er farið að fljúga til **Ma**lasíu.
Icelandair is gone to fly to Malaysia
'Icelandair has now regular flights to Malaysia.'

e002 Vegna skordýranna eru allir að segja frá **ma**lariu.
because.of the.insects are all to speak from malaria
'Because of the insects everybody speaks about malaria.'

Closed syllable: CVC

e007 Venjulega hittir prófessorinn nemendur sína í **mor**gunmat.
Usually meets the.professor students his at breakfast
'Usually the professor meets his students for breakfast.'

e008 Okkur finnst ávaxtasalat best með **man**darínum.
we.DAT find fruit.salad best with mandarines
'We like fruit salad best with mandarines.'

(6) *Target word with nuclear accent in final position; narrow focus*

Open syllable: CV

e003 Q: Hvert fór bróðir þinn í frí?
where goes brother your in holiday
'Where does your brother go on holiday?'
A: Bróðir minn fór í frí til **Ma**lasíu.
brother my goes in holiday to Malaysia
'My brother goes on holiday to Malaysia.'

e004 Q: Frá hverju sögðu læknirinn og hjúkrunarkonan?
from what spoke the.doctor and the.nurse
'What did the doctor and the nurse talk about?'
A: Læknirinn og hjúkrunarkonan sögðu frá **ma**laríu.
the.doctor and the.nurse spoke from malaria
'The doctor and the nurse spoke about malaria.'

Closed syllable: CVC

e009 Q: Hvenær borða Íslendingar hafragraut?
when eat Icelanders porridge
'When do Icelanders eat porridge?'
A: Íslendigar borða hafragraut í **mor**gunmat.
Icelanders eat porridge in breakfast
'Icelanders eat porridge for breakfast.'

e010 Q: Hvers konar köku ætlar þú að koma með?
which kind cake intend you to come with
'What sort of cake are you going to bring?'
A: Ég ætla að koma með köku með **man**darínum.
I intend to come with cake with mandarines
'I'll bring a cake with mandarines.'

(7) *Target word with prenuclear accent; broad focus*

Open syllable: CV

e005 Icelandair flýgur frá **Ma**lasíu til Reykjavíkur.
Icelandair fly from Malaysia to Reykjavík
'Icelandair has flights from Malaysia to Reykjavík.'
e006 Ferðamennirnir eru hræddir við **ma**laríu og kóleru.
the.tourists are afraid with malaria and cholera
'The tourists are afraid of malaria and cholera.'

Closed syllable: CVC

e011 Ég fæ mér kaffi með **mor**gunmat og hádegismat.
I get me.DAT coffee with breakfast and lunch
'I have coffee for breakfast and lunch.'
e012 Okkur finnst fiskur góður með **man**darínum og karrí.
we.DAT find fish good with mandarines and curry
'We like fish with mandarines and curry.'

The target sentences were presented to the participants in randomised order and were interspersed with 18 distractors.

2.1.2 Participants, apparatus and procedure

Experiment 1 was carried out in May 2008 in a quiet, closed room at the University of Iceland in Reykjavík with 12 native speakers of Icelandic (three male, nine female; S-al01–S-al12). All speakers were either students or employees at the University of Iceland and they were naïve as to the aim of the study. Their participation was voluntary. The target items were presented to the participants individually on a computer screen using Microsoft PowerPoint. They appeared on mouse-click, with the question in question–answer pairs preceding the answer. The participants were instructed to familiarise themselves with the items before reading them out loud, and to produce each sentence as naturally as possible (as if they were talking to a friend) at a normal speech rate. They read each item three times. No instructions were given as to where to place an accent or what kind of intonation to use. If a speech error was noticed during recording, the participant was asked to repeat the respective item. For question–answer pairs, both questions and answers were read by the participants. The list of target items was preceded by two practice items, one being a single sentence, the other being a

question–answer pair. The first and the last items of the actual running list read by the participants were distractors. All utterances were recorded at a sampling rate of 44100 Hz onto a Samsung laptop computer using an AKG C444 headset microphone with AKG B29L battery power supply and Cool EditTM96 software. The same software was used to edit the recordings into individual sound files. Overall, the reading study yielded 432 tokens (12 target items × 12 speakers × 3 repetitions).

2.1.3 Data treatment and analysis

All target items were analysed auditorily and instrumentally. The auditory analysis helped to identify prenuclear and nuclear pitch accent types and locations and potential speech errors. The instrumental analysis was done in Praat (Boersma 2001; Boersma & Weenink 2008), inspecting waveform, F0 contour and wideband spectrogram simultaneously. Following previous work on F0 alignment, the landmarks specified in (8) and (9) were identified on the segmental and tonal tiers. In (8), the landmarks most relevant for the analysis are bold-printed.[5]

(8) *Segmental landmarks*

C1p	beginning of onset consonant of syllable preceding target syllable
Vp	beginning of vowel of syllable preceding target syllable
C2p	beginning of final consonant of syllable preceding target syllable (where appropriate)
C1t	beginning of onset consonant of target syllable
Vt	beginning of vowel of target syllable
C2t	beginning of final consonant of target syllable (for closed target syllables only)
C1f	beginning of onset consonant of syllable following target syllable
Vf	beginning of vowel of syllable following target syllable
ef	end of syllable following target syllable

(9) *Tonal targets*

L1	beginning of F0 rise (F0 minimum preceding the local peak)
H	local F0 peak
L2	end of F0 fall (F0 minimum following the local peak)

The labelling of the segmental and tonal landmarks is illustrated in Figure 1, using a token from Experiment 1. This figure (as well as Figures 9 and 10 below) contains three tiers: a tonal tier at the top specifying the tonal landmarks as given in (9), a segmental tier specifying the segmental landmarks as given in (8), and another segmental tier at the bottom providing the words/syllables of the utterance. In the F0 contour, solid vertical lines indicate segmental landmarks, while dashed vertical lines indicate tonal landmarks.

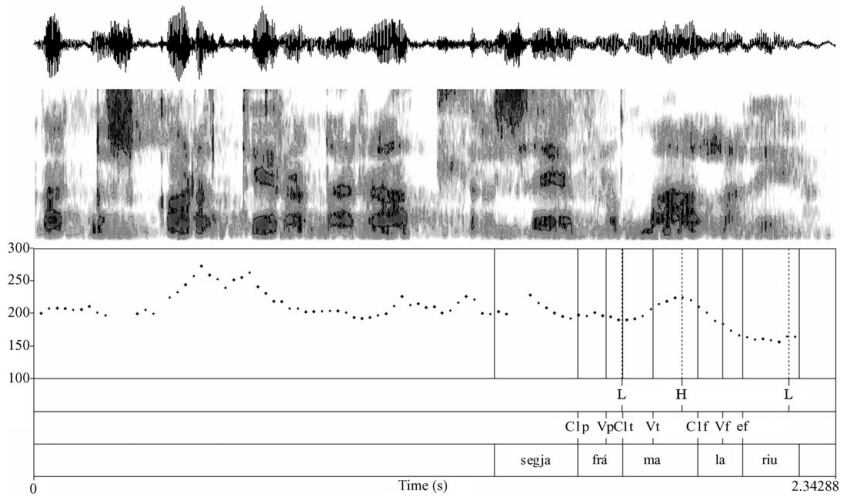

Figure 1. Item e002 (Experiment 1), speaker S-al06, female.

Due to the careful choice of experimental items, no major problems were encountered in identifying the segmental landmarks from the spectrograms and the tonal landmarks from the F0 contours. Of the 432 tokens, only seven utterances had to be discarded. Utterances were discarded if the main accent was realised on a syllable other than the target syllable (e.g., one speaker put the main accent on the preposition *frá* 'from' in one instance of e005), or if the tonal landmarks were unidentifiable. For speaker S-al11, all repetitions of item e003 had to be removed from the analysis because she produced a final rise instead of a fall, thus a different category from the other speakers, which was therefore not comparable.

The tonal landmark L2 turned out to be difficult to obtain in the prenuclear condition. This is because there is often no fall after H; instead, the F0 contour stays up towards a phrasal boundary. In these cases, no value was obtained for L2.

The F0 alignment of the tonal landmarks (L1, H, L2) was measured relative to a number of segmental landmarks, yielding variables including the ones listed in (10), which are most relevant in the present context.[6]

(10) *Alignment: variables*

L1–C1t	the distance from L1 to the beginning of the onset consonant of the target syllable
L1–Vt	the distance from L1 to the beginning of the vowel of the target syllable
H–C1t	the distance from H to the beginning of the onset consonant of the target syllable

H–Vt the distance from H to the beginning of the vowel of the target syllable
H–C1f the distance from H to the beginning of the onset consonant of the syllable following the target syllable
H–C2t the distance from H to the beginning of the final consonant of the target syllable (for closed syllables only)

The measurements performed on the basis of the segmental landmarks in order to determine the duration of the target syllable and its segments are given in (11).

(11) *Duration: variables*

C1f–C1t duration of the target (stressed) syllable
Vt–C1t duration of the onset consonant of the target syllable
C1f–Vt duration of the target vowel
et–C2t duration of the final consonant of the target syllable (closed syllables only)

Mean values were calculated for each variable and speaker, organised according to experimental condition. They were submitted to two-way analyses of variance (ANOVA) with two independent variables: (1) ACCENT TYPE/POSITION (three levels: (i) final nuclear accent, broad focus; (ii) final nuclear accent, narrow focus; (iii) prenuclear accent); (2) SYLLABLE TYPE (two levels: open/closed). Variables involving C2t were submitted to analyses of variance (ANOVA) with the independent variable of ACCENT TYPE/POSITION.

2.1.4 F0 alignment: results and discussion

This section reports on the results for the alignment of the tonal landmarks H and L1 relative to the relevant segmental landmarks. The alignment of L2 with the segmental string was analysed, but the results were inconclusive and are thus not reported. The implications for L2 as a trailing tone will be addressed in section 4 below. The overall mean F0 alignment data for L1 and H are illustrated in Figure 2 for open syllables and Figure 3 for closed syllables.

The alignment results for H are as follows. In open syllables, H is within the syllable following the accented (target) syllable in prenuclear accents. According to the mean value it is late within C1f, shortly before Vf. In nuclear accents (both broad and final narrow focus), H is within the target syllable (σt). Its position is around the beginning of Vt. According to the mean value, it is inside Vt in both broad and narrow focus accents (just after the beginning of Vt), but earlier in broad focus than in narrow focus accents.

In closed syllables, all H values are within σt, but later in prenuclear than in nuclear syllables. Specifically, in prenuclear accents, H is within C2t. In nuclear accents (both broad and final narrow focus), H is positioned early within Vt.

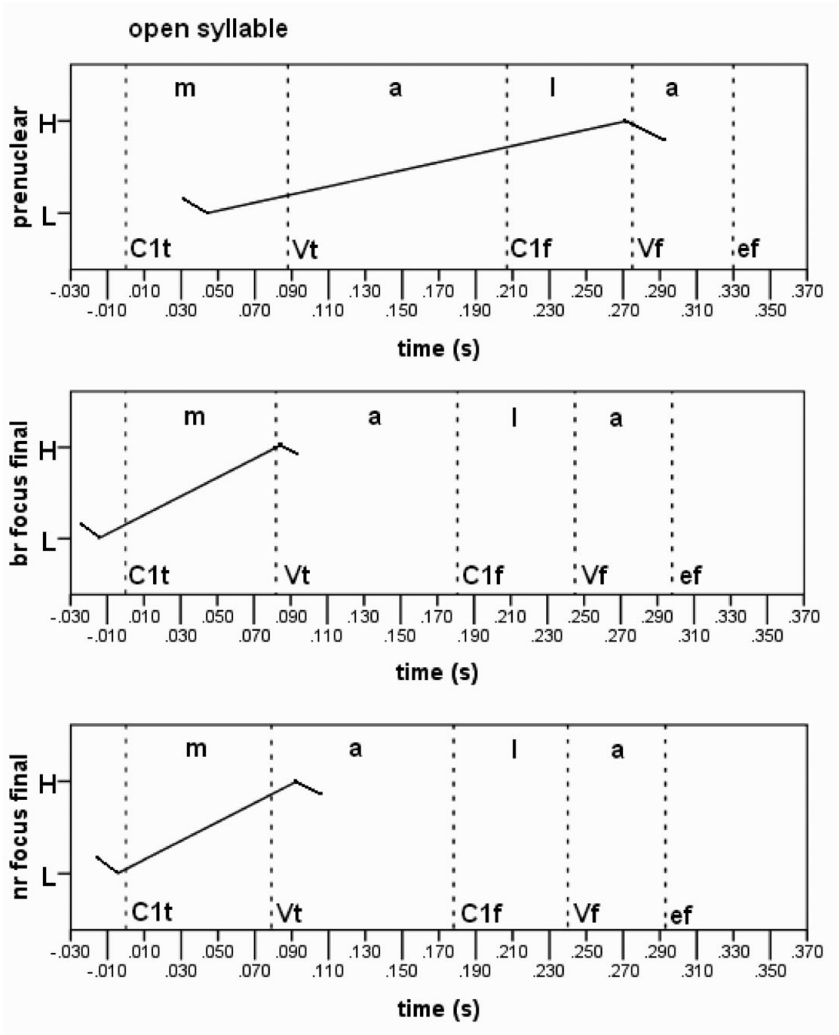

Figure 2. Experiment 1. Overall mean alignment data, open syllables (br = broad, nr = narrow); target words *Malasíu* 'Malaysia' and *malaríu* 'malaria'.

Generally speaking, H is inside Vt in nuclear accents, but within the consonant following Vt in prenuclear accents. The difference between open and closed syllables is in that due to the presence of C2t and alignment of H within C2t, H is positioned within closed σt, but it is outside open σt.

The alignment results for L1 can be summarised as follows. In open syllables, L1 is inside σt, specifically shortly after the onset in C1t, in prenuclear accents. L1 is shortly before the onset of σt in nuclear accents, both in broad and in final narrow

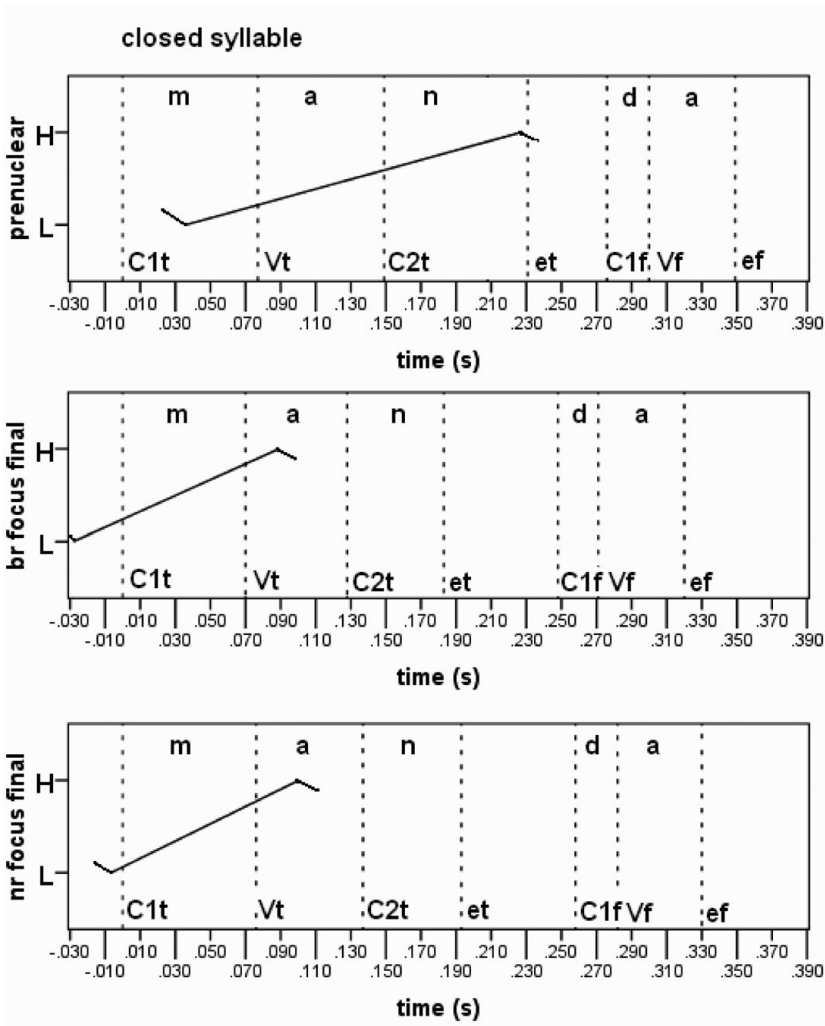

Figure 3. Experiment 1. Overall mean alignment data, closed syllables (br = broad, nr = narrow); target words *mandarínum* 'mandarines' and *morgunmat* 'breakfast'; segments illustrated here for *mandarínum*.

focus. In closed syllables, like in open syllables, L1 is inside σt shortly after the onset in C1t in prenuclear syllables. Also like in open syllables, L1 is shortly before the onset of σt in nuclear accents (both broad and final narrow focus).

The statistical analysis yielded the following results. For H–C1t, there was a main effect for ACCENT TYPE/POSITION ($F[1,11] = 76.895$, $p < .001$). SYLLABLE TYPE was not significant. There was also a significant interaction between the two

factors ($F[1,11] = 8.653$, $p < .02$). For ACCENT TYPE/POSITION, Bonferroni-adjusted post-hoc tests revealed that the main effect is due to the fact that the distance between the onset of σt and H is significantly larger in prenuclear than in nuclear accents, i.e. H is later in prenuclear accented syllables than in nuclear accented syllables, for both open and closed σt. More precisely, within both open and closed syllables, there is a difference between prenuclear and nuclear/broad focus accents, as well as between prenuclear and nuclear/narrow focus accents. The significant interaction between ACCENT TYPE/POSITION and SYLLABLE TYPE can be explained such that within the prenuclear accent, open and closed syllables differ in that the distance between the onset of σt and H is greater (H is later) in open than in closed syllables.

For H–Vt, there was a main effect for ACCENT TYPE/POSITION ($F[1,11] = 86.860$, $p < .001$). SYLLABLE TYPE was not significant. There was a marginally significant interaction between the two factors ($p < .04$). Post-hoc tests revealed the same significant differences as for H–C1t, i.e. the distance between the beginning of the vowel in the target syllable and H is significantly greater in prenuclear than in nuclear accents in both open and closed syllables.

For H–C1f, there was a main effect for ACCENT TYPE/POSITION ($F[1,11] = 96.557$, $p < .001$), as well as a main effect for SYLLABLE TYPE ($F[1,11] = 136.179$, $p < .001$) and a significant interaction between the two factors ($F[1,11] = 7.254$, $p < .025$). According to post-hoc tests, the prenuclear accent behaves significantly differently from both nuclear accent types within both open and closed syllables in the same way as described for H–C1t and H–Vt. Moreover, nuclear/broad focus differs from nuclear/narrow focus. All individual comparisons between syllable types reached significance. The significant interaction can be explained such that within closed syllables, the individual comparison between broad and narrow focus nuclear syllables did not reach significance.

The results show a clear difference between the prenuclear accent on the one hand and the two final nuclear accents on the other hand, with the F0 peak being reached earlier in final nuclear position than in prenuclear position.

There were no significant effects for any of the variables involving L1. L1 is located around the beginning of the target syllable in all conditions as outlined above. It is, however, inside the stressed syllable (C1t) in prenuclear position, and just before C1t in nuclear final position.

The difference between early and late F0 peaks suggests a difference in meaning such that the late peak is prenuclear, non-focal, and indicates continuation of the utterance, while the early peak signals nuclear status and focus near the end of the utterance. However, in this experiment, non-nuclear and nuclear accents were not tested in the same position. The alignment of H in final accents is probably also affected by its proximity to a strong prosodic boundary, i.e. its utterance-final position. Nuclear and non-nuclear (prenuclear) accents in identical position were therefore compared in Experiment 2 (see section 2.2 below).

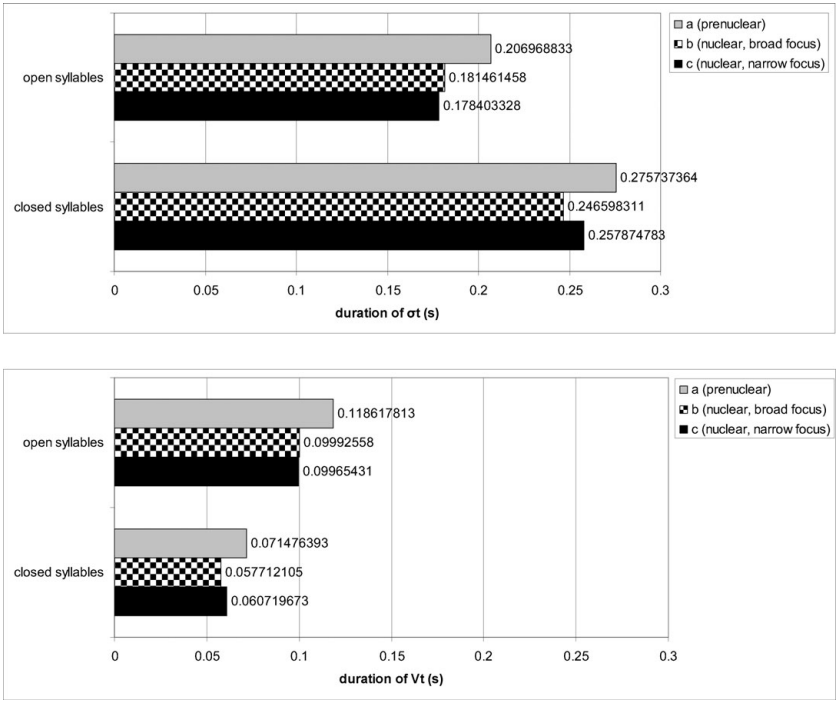

Figure 4. Duration of σt (upper panel) and Vt (lower panel).

2.1.5 Duration: results and discussion

The mean values for duration are summarised in Figure 4 for the accented syllable (σt; upper panel) and the vowel of σt (Vt; lower panel). The charts reveal that overall, higher duration values were obtained in prenuclear position, than in final nuclear position. Furthermore, closed syllables were longer than open ones, but the vowel was longer in open syllables. In the statistical analysis for σt, main effects were obtained for ACCENT TYPE/POSITION ($F[1,11] = 12.857$, $p < .005$) and for SYLLABLE TYPE ($F[1,11] = 555.660$, $p < .001$). Post-hoc tests revealed that the main effect for accent type was due to the difference between the duration of a prenuclear σt on the one hand and the duration of a sentence-final nuclear σt on the other hand. In open syllables, σt was significantly longer in prenuclear position than in final nuclear position/broad focus, and it was significantly longer in prenuclear position than in final nuclear/narrow focus position. The comparison between the two final nuclear conditions did not reach significance. Within closed syllables, the comparison between prenuclear σt and nuclear final/broad focus σt reached significance. Within accent types, all comparisons between syllable types reached significance, indicating that closed syllables are longer than open syllables.

Similarly for Vt, main effects were obtained for ACCENT TYPE/POSITION ($F[1,11] = 37.564$, $p < .001$) and for SYLLABLE TYPE ($F[1,11] = 276.661$, $p < .001$). Post-hoc tests revealed that the main effect for ACCENT TYPE/POSITION was due to the differences between prenuclear syllables on the one hand and nuclear syllables (both broad and narrow focus) on the other hand. This was true for both open and closed syllables. The two nuclear conditions did not differ significantly. Regarding SYLLABLE TYPE, Vt is longer in open syllables than in closed.

An ANOVA for C2t with the factor ACCENT TYPE/POSITION did not reach significance. The analysis for C1t yielded no relevant effects, either.

The effects for SYLLABLE TYPE follow straightforwardly from the syllabic make-up as outlined in section 2.1.1 above. Regarding the duration of σt, the rhyme of open syllables is made up of a long vowel, while the rhyme of a closed syllable is made up of a short vowel and a lengthened 'half-long' consonant. It seems that more segmental material may take more time. Regarding the duration of Vt, closed syllables have structurally short vowels which cannot be lengthened under stress, while vowels in open syllables are structurally long, thus inherently longer than vowels in closed syllables, and in addition they can be lengthened under stress.

As for the effects for ACCENT TYPE (prenuclear syllables/vowels are longer than final nuclear ones), there are at least two ways of looking at the results: first, in terms of nuclear stress, such that nuclear syllables are shorter than prenuclear ones; second, in terms of position, such that final syllables are shorter than non-final ones. Both options are somewhat surprising, given the amount of literature reporting both lengthening of the last stressed syllables in a phrase (e.g., Vaissière 1983), and of focused constituents as compared to non-focused ones (e.g., Klatt 1976; Cooper et al. 1985; Féry & Kügler 2008). This issue will be further discussed in sections 2.2.4 and 4 below, in light of the direct comparison between nuclear and prenuclear syllables in identical position addressed in Experiment 2.

2.2 Experiment 2

The main purpouse of this study was to compare the prenuclear rise with a nuclear accent in the same position, and to compare narrow focus accents in different positions.

2.2.1 Materials

The items with broad focus and nuclear accent in final position of the previous study (see (5) above) were replaced by sentences with narrow focus in prefinal position (see (12) below). The rest of the material was identical to the material used in Experiment 1, given in (6) and (7) above, repeated below for convenience.

The new set of experimental items (in (12)) was lexically identical to the prenuclear condition in (7) and (14), except that the target sentences were preceded

by a context question focusing on the constituent in prefinal position. Specifically, the materials of this study allow for direct comparison between a nuclear accent and a prenuclear accent in the same position ((12) compared with (14)), and between a narrow focus nuclear accent in prefinal position and a narrow focus nuclear accent in sentence-final position ((12) compared with (13)). All target sentences of Experiment 2 are given in (12)–(14). As above, target syllables are in bold face.

(12) *Target word with nuclear accent in prefinal position; narrow focus*

Open syllable: CV

e001 Q: Flýgur Icelandair frá Noregi til Reykjavíkur?
fly Icelandair from Norway to Reykjavík
'Does Icelandair have flights from Norway to Reykjavík?'
A: Nei, Icelandair flýgur frá **Ma**lasíu til Reykjavíkur.
no Icelandair fly from Malaysia to Reykjavík
'No, Icelandair has flights from Malaysia to Reykjavík.'

e002 Q: Eru ferðamennirnir hræddir við plágu og kóleru?
are the.tourists afraid with plague and cholera
'Are the tourists afraid of plague and cholera?'
A: Nei, ferðamennirnir eru hræddir við **ma**laríu og kóleru.
no the.tourists are afraid with malaria and cholera
'No, the tourists are afraid of malaria and cholera.'

Closed syllable: CVC

e007 Q: Færðu þér kaffi með kvöldmat og hádegismat?
get.you your.DAT.SG coffee with dinner and lunch
'Do you have coffee with dinner and lunch?'
A: Nei, ég fæ mér kaffi með **mor**gunmat og hádegismat.
no I get me.DAT coffee with breakfast and lunch
'No, I have coffee with breakfast and lunch.'

e008 Q: Finnst ykkur fiskur góður með tómatum og karrí?
find you.DAT.PL fish good with tomatoes and curry
'Do you like fish with tomatoes and curry?'
A: Nei, okkur finnst fiskur góður með **man**darínum og karrí.
no we.DAT find fish good with mandarines and curry
'No, we like fish with mandarines and curry.'

(13) *Target word with nuclear accent in final position; narrow focus* (= (6))

Open syllable: CV

e003 Q: Hvert fór bróðir þinn í frí?
where goes brother your in holiday
'Where does your brother go on holiday?'
A: Bróðir minn fór í frí til **Ma**lasíu.
brother my goes in holiday to Malaysia
'My brother goes on holiday to Malaysia.'

e004 Q: Frá hverju sögðu læknirinn og hjúkrunarkonan?
from what spoke the.doctor and the.nurse
'What did the doctor and the nurse talk about?'
A: Læknirinn og hjúkrunarkonan sögðu frá **ma**laríu.
the.doctor and the.nurse spoke from malaria
'The doctor and the nurse spoke about malaria.'

Closed syllable: CVC

e009 Q: Hvenær borða Íslendingar hafragraut?
when eat Icelanders porridge
'When do Icelanders eat porridge?'
A: Íslendigar borða hafragraut í **mor**gunmat.
Icelanders eat porridge in breakfast
'Icelanders eat porridge for breakfast.'
e010 Q: Hvers konar köku ætlar þú að koma með?
which kind cake intend you to come with
'What sort of cake are you going to bring?'
A: Ég ætla að koma með köku með **man**darínum.
I intend to come with cake with mandarines
'I'll bring a cake with mandarines.'

(14) *Target word with prenuclear accent; broad focus* (= (7))

Open syllable: CV

e005 Icelandair flýgur frá **Ma**lasíu til Reykjavíkur.
Icelandair fly from Malaysia to Reykjavík
'Icelandair has flights from Malaysia to Reykjavík.
e006 Ferðamennirnir eru hræddir við **ma**laríu og kóleru.
the.tourists are afraid with malaria and cholera
'The tourists are afraid of malaria and cholera.'

Closed syllable: CVC

e011 Ég fæ mér kaffi með **mor**gunmat og hádegismat.
I get me.DAT coffee with breakfast and lunch
'I have coffee for breakfast and lunch.'
e012 Okkur finnst fiskur góður með **man**darínum og karrí.
we.DAT find fish good with mandarines and curry
'We like fish with mandarines and curry.'

The target sentences were interspersed with 10 distractors. They were presented to the participants in randomised order except that each item of type (14) was followed by the corresponding item of type (12), and the participants were familiarised with this kind of contrasting context by one of two practise items which preceded the experimental set.

2.2.2 Participants, apparatus and procedure

Experiment 2 was carried out in August 2009 in a quiet, closed room at the University of Iceland in Reykjavík with 12 native speakers of Icelandic (five male, seven female; 2009_Sp01–2009_Sp12). None of the speakers who participated in Experiment 2 had also participated in Experiment 1. All speakers were graduate students at the University of Iceland. Their participation was voluntary. The procedure and apparatus were the same as for reading Experiment 1. Like Experiment 1, Experiment 2 yielded 432 tokens overall (12 target items × 12 speakers × 3 repetitions).

2.2.3 Data treatment and analysis

The data were treated and analysed in the same way as for Experiment 1. Of the 432 tokens, 14 utterances had to be discarded from the analysis. For speaker 2009_Sp03, item e003 had to be completely removed from the analysis because he had produced incomplete target sentences. (He refused to include *í frí* 'on holiday' in the answer sentence because it was part of the question.)

2.2.4 F0 alignment: results and discussion

The overall mean F0 alignment data for L1 and H are illustrated in Figure 5 for open syllables and Figure 6 for closed syllables. For the items that are identical in the two studies, Experiment 2 repeats the results of Experiment 1. As before, the results for L2 are inconclusive and are thus not reported.

The following patterns emerge for H. In open syllables, H is within the syllable following σt in prenuclear accents. According to the mean value, it is within C1f. In nuclear accents (both prefinal and final narrow focus), H is within Vt, but earlier in final nuclear accents than in prefinal nuclear accents. In closed syllables, all H values are within σt. H is in C2t in both prefinal accents, i.e. the prenuclear and the nuclear one, but later in the prenuclear one. H is in Vt in nuclear final syllables.

As in Experiment 1, the difference between open and closed syllables is that due to the presence of C2t, H is positioned in σt in closed syllables, but it is outside σt in open syllables.

The results for L1 are as follows. In open syllables, L1 is inside σt, specifically shortly after the onset in C1t, in prenuclear accents and in prefinal nuclear accents; it is earlier in prefinal nuclear accents than in prenuclear accents. L1 is located just before C1t in final nuclear accents. In closed syllables, L1 is inside the target syllable shortly after the onset in C1t in prenuclear syllables. L1 is before the onset of C1t in both prefinal and final nuclear conditions.

The statistical analysis yielded the following results. For H–C1t, there was a main effect for ACCENT TYPE/POSITION ($F[1,11] = 26.253$, $p < .002$), but no main effect for SYLLABLE TYPE. The interaction between the two factors reached significance

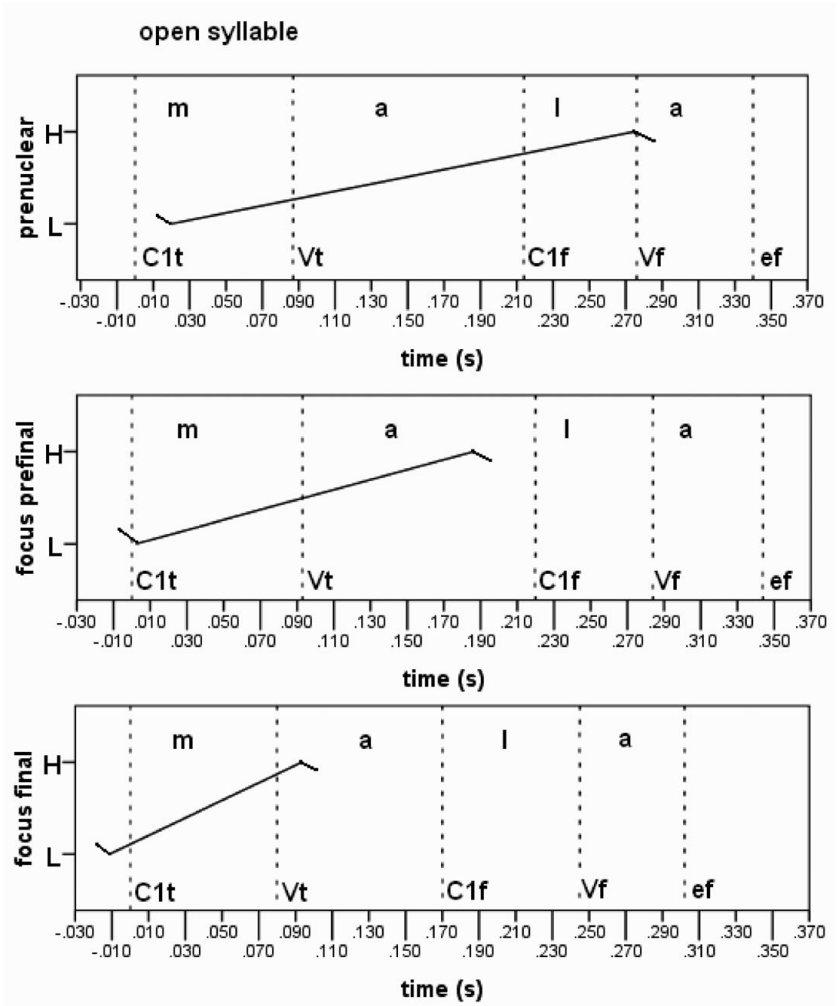

Figure 5. Experiment 2. Overall mean alignment data, open syllables; target words *Malasíu* 'Malaysia' and *malaríu* 'malaria'.

($F[1,11] = 6.569$, $p < .03$). Post-hoc tests revealed that for both open and closed syllables, the main effect for ACCENT TYPE/POSITION was due to the significant differences between prenuclear and final nuclear syllables as well as between prefinal nuclear and final nuclear. Comparisons between the two prefinal conditions (prenuclear vs. nuclear) did not reach significance for either open or closed syllables.

For H–Vt, there was a main effect for ACCENT TYPE/POSITION ($F[1,11] = 19.680$, $p < .002$). SYLLABLE TYPE was not significant and there was no significant interaction between the two factors. The effect was due to the same significant differences as

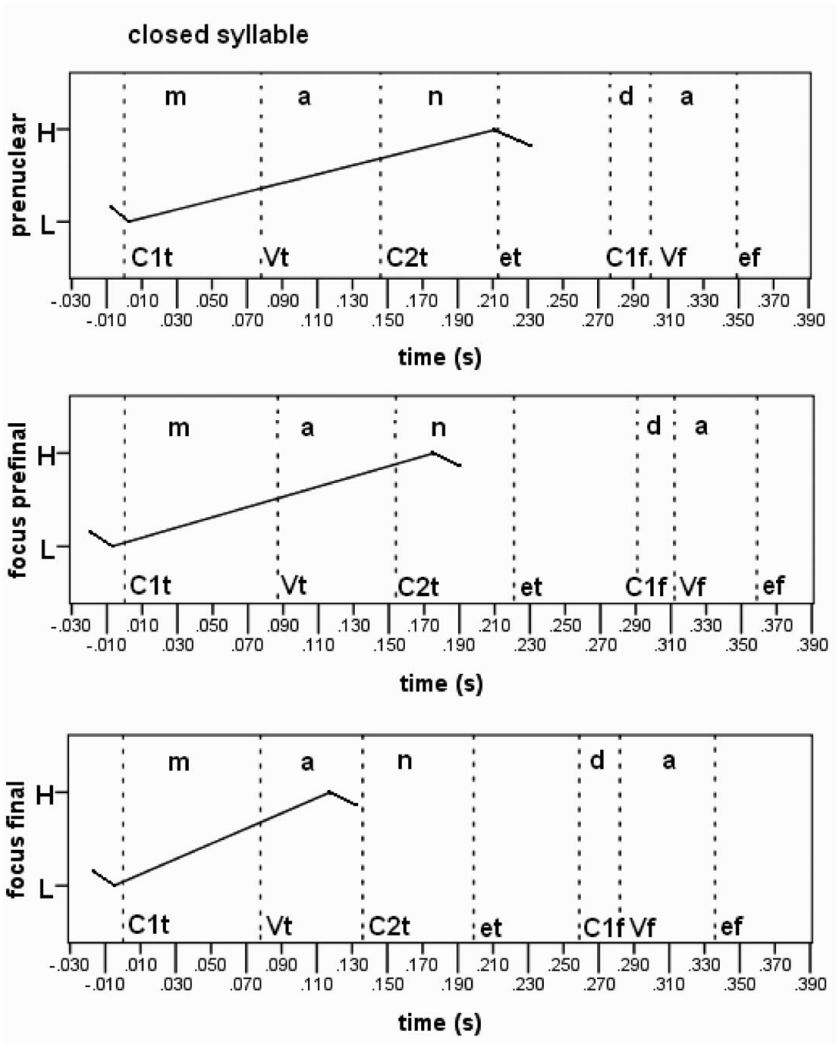

Figure 6. Experiment 2. Overall mean alignment data, closed syllables; target words *mandarínum* 'mandarines' and *morgunmat* 'breakfast'; segments illustrated here for *mandarínum*.

for H–C1t, i.e. the distance between the beginning of the vowel in the target syllable and H is significantly greater in prenuclear than in final nuclear accents and in prefinal nuclear than in final nuclear accents in both open and closed syllables. The comparison between prenuclear syllables and prefinal nuclear syllables did not reach significance for either open or closed syllables.

For H–C1f, there were main effects for ACCENT TYPE/POSITION ($F[1,11] = 21.807, p < .002$) and SYLLABLE TYPE ($F[1,11] = 60.797, p < .001$). There was no significant interaction between the two factors. Post-hoc tests revealed significant differences for each pair within open syllables. Specifically, H is significantly later in prenuclear syllables than in nuclear syllables in the same prefinal position; H is significantly later in prenuclear syllables than in nuclear syllables in final position; and H is significantly later also in prefinal nuclear syllables than in final nuclear syllables. Within closed syllables, there is no significant difference between the two prefinal conditions (prenuclear vs. nuclear). The other two comparisons reached significance: H is later in prenuclear than in nuclear final syllables and H is later in prefinal nuclear syllables than in final nuclear syllables.

For H–C2t, a main effect was obtained for ACCENT TYPE/POSITION ($F[1,11] = 9.349$, $p < .015$). This was due to significant differences between prenuclear and nuclear final and between prefinal nuclear and final nuclear, which is in line with the positional differences: H is in C2t in the two prefinal accents, but in Vt in final nuclear syllables.

For L1–C1t and L1–Vt, main effects were obtained for ACCENT TYPE/POSITION (L1–C1t: $F[1,11] = 8.429, p < .015$; L–Vt: $F[1,11] = 5.982, p < .035$). These effects are due to significant differences within open syllables between prenuclear syllables and final narrow focus syllables. All other individual comparisons failed to reach significance.

It is striking that there is relatively little statistically significant difference between the two prefinal conditions with respect to the F0 alignment of H. In descriptive terms, one obvious difference is that in open syllables, H is aligned in Vt in prefinal nuclear accents, but in C1f in prenuclear syllables. This difference disappears in closed syllables. The question arises whether the differences in the way pitch movements are aligned with the segmental string can, in this case, convey intonational distinctions, specifically distinctions between non-nuclear and nuclear accents in the same position. A perception study testing this question will be reported on in section 3, revealing that listeners have no problems with correctly categorising the accents.

2.2.5 Duration: results and discussion

The mean values for duration are summarised in Figure 7 for σt and Vt. The charts reveal that overall, higher duration values were obtained in the two prefinal positions, regardless of whether or not this was also the position of the focus. Furthermore, as in Experiment 1, closed syllables are longer than open ones, but the vowel is longer in open syllables. This was confirmed by the results of the statistical analysis. For σt, main effects were obtained for ACCENT TYPE/POSITION ($F[1,11] = 27.280, p < .001$) and for SYLLABLE TYPE ($F[1,11] = 157.436$, $p < .001$). Post-hoc tests revealed no

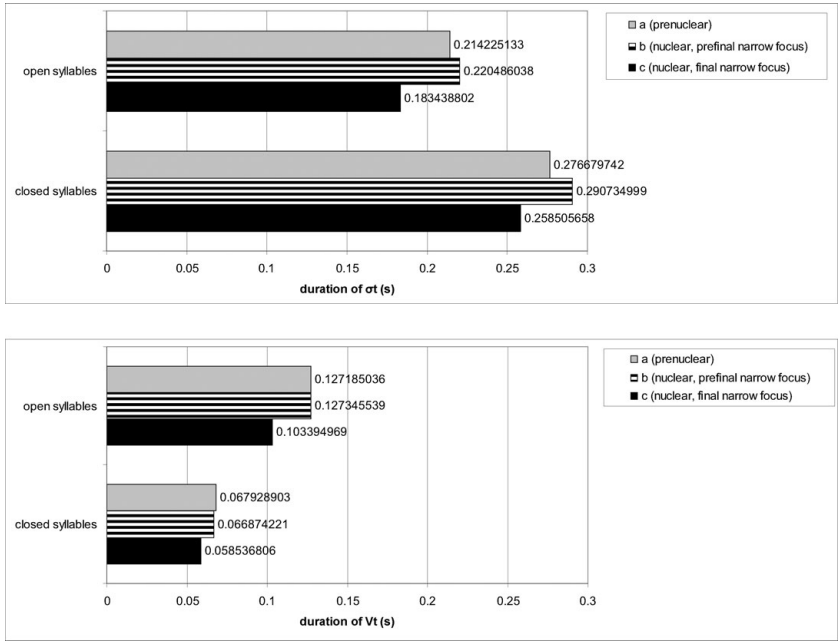

Figure 7. Duration of σt (upper panel) and Vt (lower panel).

significant difference between the prenuclear condition and the prefinal narrow focus condition for either open or closed syllables. Instead, significant results were obtained such that within open syllables, prenuclear syllables were longer than nuclear syllables in final position and prefinal nuclear syllables were longer than nuclear syllables in final position. Within closed syllables, prefinal nuclear syllables were longer than nuclear syllables in final position. Within accent types, all comparisons reached significance, indicating that closed syllables are longer than open syllables.

Similarly for Vt, main effects were obtained for ACCENT TYPE/POSITION ($F[1,11] = 108.680$, $p < .001$) and for SYLLABLE TYPE ($F[1,11] = 101.740$, $p < .001$). The interaction between the two factors also reached significance ($F[1,11] = 20.907$, $p < .002$). As for σt, post-hoc tests revealed no significant difference between the prenuclear condition and the prefinal focus condition for either open or closed syllables. Within open syllables, Vt in final focus syllables was shorter than both Vt in prenuclear syllables and Vt in prefinal nuclear syllables. The same holds for closed syllables. Within accent types, Vt in closed syllables is significantly shorter than Vt in open syllables.

No effects were obtained for either C1t or C2t.

These results suggest that it is position rather than focus which affects syllable and vowel duration. No difference was found between focused and non-focused constituents in the same position. It follows that unlike other languages, Icelandic does not make use of the duration of the stressed syllable to signal focus. Notice that previous work has already exposed another difference between Icelandic focus constructions and those in English, German and other related languages: Icelandic does not necessarily deaccent post-focal, given information (Nolan & Jónsdóttir 2001; Dehé 2009). Also, compared to other languages, Icelandic shows the reverse effects with respect to the relation between duration and position. While other languages show domain-final lengthening of stressed syllables, syllables in Icelandic are longer in prefinal than in final position.[7]

3. PERCEPTION

A perception study was designed in order to test listeners' abilities to distinguish between prenuclear pitch accents and prefinal nuclear accents in the same position. The study used stimuli taken from Experiment 2.

3.1 Materials

The stimuli were the eight items given in (12) and (14) above, targeting the prenuclear accent (see (14)) and the prefinal nuclear accent (see (12)). They were taken from the data produced by three female speakers who had taken part in Experiment 2 (2009_Sp01, 2009_Sp08 and 2009_Sp10). For each target item, one utterance was selected from each speaker, yielding 24 stimuli. In addition, two practice items were chosen. From each utterance, the target noun (*Malasíu*, *malaríu*, *morgunmat*, *mandarínum*) was extracted. Two sets of stimuli were prepared: one containing full utterances, the other containing individual words. Each set of stimuli was organised such that two items which were lexically identical did not occur in an uninterrupted sequence, that no more than two items of the same experimental condition occurred in a row, and that there were no sequences of more than three items produced by the same speaker. In the actual experiment, the set of full utterances preceded the set of individual words.

A questionnaire was prepared which started with instructions. To begin with, the listeners were told that they were going to hear sentences which might be either an out-of-the-blue utterance or the answer to a question given on the questionnaire. These questions were identical to the context questions in (12). The instructions were followed by two practice items, which were then followed by the 24 target items. This first set was followed by another instructive paragraph, which told listeners that they were now going to hear single words which were taken from the same contexts as before. As before, the listeners were asked to mark the version on the

questionnaire that they thought the word was extracted from. Like the set of full utterances, this second set was preceded by two practice items. The list of words was presented in a slightly different order than the list of full sentences in order to discourage participants from going back to their previous answers.

3.2 Participants, apparatus and procedure

Like Experiment 2, the perception test was carried out in August 2009 in a quiet, closed room at the University of Iceland in Reykjavík. Seven native speakers of Icelandic (four male, three female), all graduate students at the University of Iceland, were tested. Their participation was voluntary. None of the listeners who participated in the perception study had also participated in a production study (i.e., in Experiment 1 or Experiment 2).

The listeners were provided with a questionnaire of 13 pages, which contained the instructions and the actual stimuli. For each stimulus, two contexts were presented: out-of-the-blue on the left, and context question plus stimulus on the right. The participants were asked to mark the version from which they thought the sentence/word had been taken. They heard the stimuli from loudspeakers connected to a Samsung laptop computer. Listeners were allowed to hear each utterance up to three times but were encouraged to base their choice on their first impression.

3.3 Results and discussion

Of the 168 tokens (24 target items $\times$ 7 listeners) of set 1 (full utterances), 164 sentences (97.6%) were identified correctly. Four participants identified all sentences correctly, one speaker misidentified two sentences, and two speakers misidentified one sentence each. Of the 168 tokens of set 2 (single target words), 161 (95.8%) were identified correctly. Four participants identified all words correctly, one speaker misidentified three words, and two speakers misidentified two words each.

These results clearly show that listeners can easily distinguish a broad focus sentence from a sentence containing a prefinal nuclear focus, and also a word carrying a focus accent from a word used in a prenuclear context, on the basis of the natural utterance alone. Based on the production results, which left open some questions regarding the differences between a prefinal focus accent and a prenuclear accent, it was the aim of this perception study to see whether categorial responses could be elicited from listeners based on the production data. It is important to note that not only the full utterance condition but also the single word condition reached a very high percentage of correctly identified items, suggesting that the accent on the target word provides a large portion of information for the hearer, which may be complemented by information drawn from the rest of the utterance.

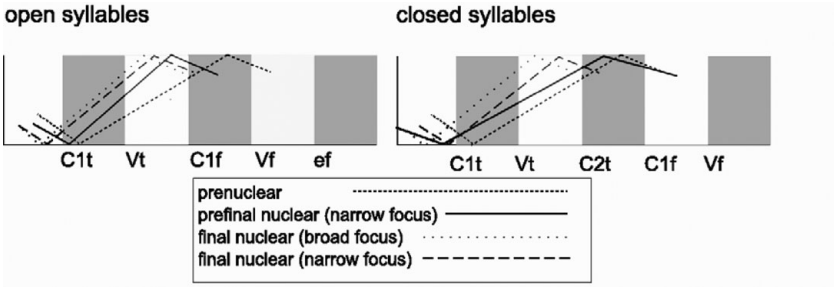

Figure 8. Schematic representation of the eight pitch accents according to the combined measurement results of Experiments 1 and 2; segment durations are idealised.

4. GENERAL DISCUSSION

The results for alignment of L1 and H with segmental landmarks from the two experiments are combined in the schematic representation in Figure 8.[8] All conditions reveal stable alignment of L1 with the segmental string. While the statistical analyses did not reveal differences between the accent types in this respect, the actual alignment is such that L is just after the onset of C1t in prenuclear accents, but before the onset of C1t in nuclear final accents. For the prefinal nuclear accent, L is inside C1t in open and before C1t in closed syllables. The position of H is more variable, but equally consistent within conditions. H is inside the vowel of the accented syllable in nuclear syllables in final position, and in open nuclear syllables in prefinal position, and H is in the following consonant in prenuclear syllables and closed prefinal nuclear syllables; see Figure 8. There is no consistent alignment of L2. In other words, all accent types show a rise from L to H, but H is reached earlier in nuclear accents than in prenuclear accents.

These results are reminiscent of much of the recent literature on F0 alignment. For example, the stable alignment of L at the beginning of the stressed syllable was also the result of studies on a number of other languages, and so was the more variable alignment of H (e.g., Prieto et al. 1995; Arvaniti et al. 1998; Ladd et al. 1999; Ladd et al. 2000). Second, the fact that H is reached later in prenuclear accents than in nuclear accents has been observed for other languages, too (e.g., Silverman & Pierrehumbert 1990 for English). Third, the difference between open and closed syllables for the position of H in prenuclear accents is reminiscent of Hellmuth's (2006) results for Egyptian Arabic, and Ladd et al.'s (2000) results for Dutch.[9]

4.1 Intonational distinctions in Icelandic

Based on the evidence from the experiments reported on above, the following intonational distinctions can be identified for Icelandic.

First, no contrast was found for F0 alignment or syllable/segment duration between a sentence-final nuclear accent in a broad focus sentence on the one hand and a final narrow focus on the other hand. In the case of the tonal events, the beginning of the local F0 rise was located just before C1t and the peak was reached in Vt in both conditions. Perceptually, this accent is a final fall (Haugen 1958; Árnason 1998a). No evidence was found that the end of the fall was consistently reached before the end of the second syllable of the target word.

Second, there is a slight difference between prefinal nuclear accents and final nuclear accents. This is illustrated by Figure 9 (panel a: prefinal nuclear; panel b: final nuclear) with two utterances from speaker 2009_Sp01, Experiment 2. While the shape of the two accents is very similar, the tonal event is later in prefinal position than in final position. Specifically, L1 is within the onset consonant of the accented syllable in prefinal position, but just before the onset in final position. H is reached later in the vowel of the target syllable in prefinal than in final position. The alignment differences reach statistical significance for the position of H. The fact that final nuclear accents behave alike but that they differ from the prefinal nuclear accent suggests that the effect is due to the position of the accented syllable in the sentence: remember from section 1 that according to previous research, peak alignment is earlier before a stronger prosodic boundary than before a weaker prosodic boundary. Here, the final nuclear syllable, but not the prefinal nuclear syllable, is followed by an utterance boundary. Syllable and vowel duration add to the contrast between final nuclear and prefinal nuclear syllables such that prefinal nuclear syllables and their vowels are longer than final nuclear syllables and their vowels. Like alignment, duration is affected by position. The effect found throughout is final shortening.

Third, a prenuclear accent was found to be different from a final nuclear accent, such that the prenuclear accent is represented by a late F0 peak and the final nuclear one by an early peak with a subsequent fall. Perceptually (confirmed by my Icelandic native-speaking informants), the prenuclear accent is a rise from a low accented syllable. Durational differences were also found between the two conditions, such that prenuclear accented syllables were longer than final nuclear syllables, and similarly, vowels in prenuclear accented syllables were longer than vowels in final nuclear syllables. Here again, it is the earlier accent (and the non-focus one) that goes along with longer durations.

Fourth, nuclear accents in prefinal position (see Figure 9, panel a) differ from prenuclear accents in the same position (see Figure 10) in at least two ways. First, H is aligned later in prenuclear accents than in prefinal nuclear accents, even if this difference fails to reach significance in most comparisons. Another difference between the two accent types is the F0 contour following the relevant accents. In prefinal nuclear accents, an immediate fall on the target word to a low level in the speaker's tonal range can be observed, while in prenuclear accents,

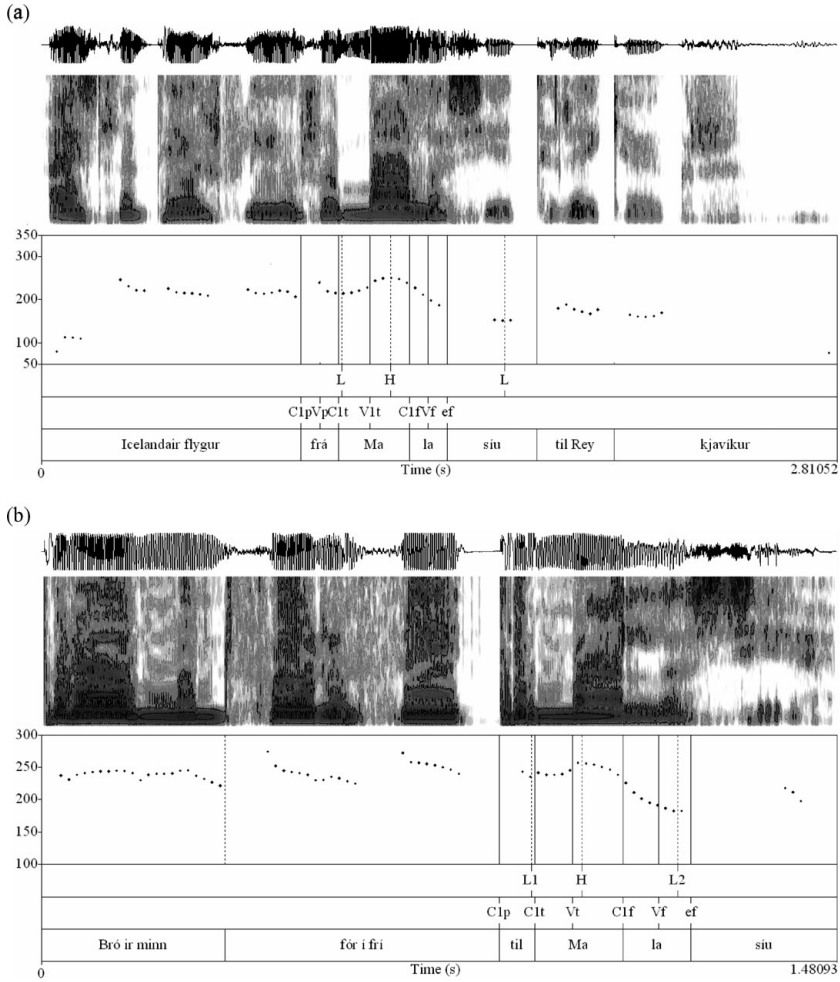

Figure 9. Prefinal nuclear accent (panel a) vs. final nuclear accent (panel b); speaker 2009_Sp01 (female). (a) Item e001 (Experiment 2): *Icelandair flýgur frá Malasíu til Reykjavíkur* 'Icelandair has flights from Malaysia to Reykjavík' (prefinal nuclear); (b) Item e003 (Experiment 2): *Bróðir minn fór í frí til Malasíu* 'My brother goes on holiday to Malaysia' (final nuclear).

there is no such rapid downward pitch movement. These differences between the contours explain the unambiguous results of the perception study reported on in section 3 above. Finally, it should be noted that there are no durational effects relevant to the contrast between prenuclear and prefinal nuclear syllables, neither for the duration of the accented syllable, nor for vowel duration. This finding confirms that it is position rather than focus which affects syllable/segment duration.

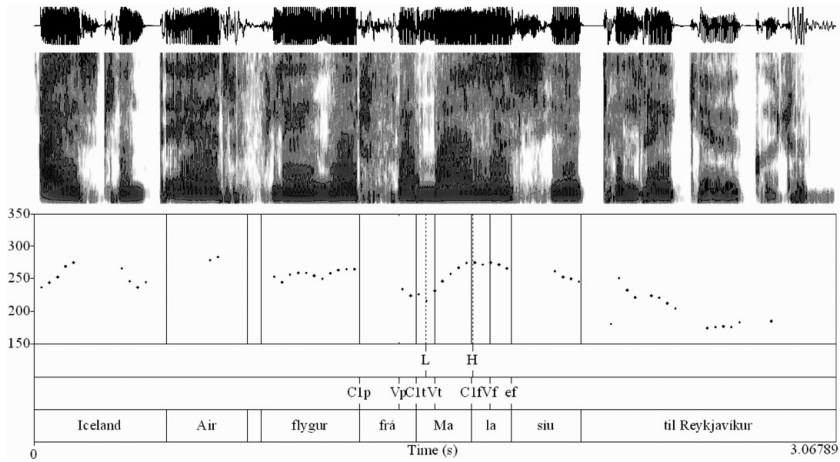

Figure 10. Prenuclear accent; speaker 2009_Sp01 (female); item e005 (Experiment 2): *Icelandair flýgur frá Malasíu til Reykjavíkur* 'Icelandair has flights from Malaysia to Reykjavík' (prenuclear).

4.2 Accent types

All accents are rises from L to H. The experimental results do not provide evidence for a stable alignment of L2 in the right vicinity of H, thus no evidence for a low trailing tone. What is perceptually a fall is therefore analysed here as a fall to a low edge tone.

With respect to the alignment differences reported on above, the question arises whether they translate into categorial distinctions, specifically a distinction between L*H and LH*. The meaning and theoretical status of the star notation, introduced by Pierrehumbert (1980), is less than clear (see Arvaniti, Ladd & Mennen 2000; Ladd 2008:184–188) and the L*H/LH* distinction in particular has been extensively discussed in recent literature (e.g., Arvaniti et al. 2000; Atterer & Ladd 2004). Atterer & Ladd (2004:194) maintain that '[n]otational distinctions such as L*+H vs. L+H* . . . may . . . be useful for preliminary impressionistic transcription [but] are incapable of representing the range of fine phonetic differences that can be discovered instrumentally' and of representing the finding that cross-linguistically, there is a continuum of phonetic alignment.

Despite these concerns and taking into account the Icelandic-specific contrasts of alignment in combination with the perceptual facts, I suggest transcribing the accent types studied here as follows.

The prenuclear accent is transcribed as L*H: a rise from a low accented syllable. This analysis is supportive of the original analysis of this accent as L*H by Árnason (1998a) and Dehé (2009). Phonetic evidence comes from the stable alignment of L

in C1t, and the equally stable alignment of H in the consonant following Vt, i.e. the onset consonant of the next syllable in open stressed syllables, and the consonant complementing the nucleus of the stressed syllable in closed syllables. The L*H analysis is consistent with the assumption that the starred tone is linked to the stressed syllable such that it is temporally aligned with it. It is also consistent with the fact that Icelandic prenuclear accents sound rising from low.

The final nuclear accent is transcribed here as LH* followed by a low edge tone (L%). The strict alignment of L1 just before the beginning of the stressed syllable, the fixed position of H within Vt and the fact that there is no stable alignment between L2 and a segmental landmark all serve as phonetic evidence for LH*. The analysis of H as the central tone of the pitch accent and the fall to a low edge tone is in line with earlier work on Icelandic, which on the basis of perceptual evidence reports a local pitch peak to mark the accent and a fall at the end of the utterance (Haugen 1958: 74). It is also compatible with more recent work, still based primarily on intuitive and perceptual evidence, which analyses the same accent as H*L (Árnason 1998a; Dehé 2009).[10] This previous analysis as H*L differs from the present analysis in that there is a trailing tone but no leading tone. H*L has been suggested on the perceptual basis that the accent is a local peak followed by a rapid fall to a low level, and that the fall is usually completed on the syllable following the stressed one. For the latter point, no consistent phonetic evidence was found in the present study. The first point is certainly true but does not necessarily justify the assumption of a trailing tone. The rapid fall can be argued to be towards a low edge tone.

Finally, I transcribe the nuclear accent in prefinal position as LH* with a subsequent fall to a low edge tone. The stable alignment of L1 and the stable position of H within Vt serve as phonetic evidence. This is the same accent type as in nuclear accents in final positions. Based on previous research, the variation in peak alignment, i.e. later alignment in prefinal than in final nuclear accents, is ascribed to the position in the sentence and the corresponding effect of the prosodic boundary. Perceptually, unlike the prenuclear accent, the prefinal nuclear accent sounds high, and prefinal/nuclear vs. prenuclear were easily identified in the perception study.

On the basis of the current evidence, no further accent types can be identified. In particular, whether Icelandic has the monotonal accents H* and L* and whether they are phonologically distinct from the accent types identified here, is a topic for future research.

5. SUMMARY, CONCLUSION AND OUTLOOK

The preceding sections reported on the findings of two production studies and one perception study, which were designed to test F0 alignment and segment duration in Icelandic pitch accents in four different conditions. The results were interpreted as

follows. First, the Icelandic prenuclear accent is a rise from a low accented syllable (L*H), confirming earlier results based primarily on intuitive and perceptual data (Árnason 1998a; Dehé 2009). Second, nuclear accents are early rises followed by an immediate fall, both in final and prefinal position. The difference in peak alignment such that H is later in prefinal than in final nuclear accents is attributed to the position of the target noun in the sentence and its respective proximity to a strong prosodic boundary. This accent is the one analysed in earlier work as H*L and H* on the perceptual basis that there is a fall from a high accented syllable, either immediately after the peak on the next syllable or somewhat delayed.

In addition, the results of the measurements of syllable and segment duration suggest a positional (final shortening) effect but no focus effect. Target syllables and their vowels positioned earlier in the sentence are longer than later ones, regardless of focus.

While these results shed new light on the tonal inventory of Icelandic and its intonational categories as well as length effects, some questions remain open for future research. One question concerns the possible differences between prenuclear L*H as identified here and nuclear L*H. Árnason (1998a) and Dehé (2009) observe L*H as a nuclear accent in, for example, *yes*/*no*-questions, see (15a) (from Árnason 1998a:53) and (15b) (from Dehé 2009:29).

(15) a. Er Dísa komin?
L*H L%
is Dísa come
'Has Dísa arrived?'

b. Gaf Jón Hildi banana?
L*H L%
gave Jón Hildur a.banana
'Did Jón give Hildur a banana?'

With regard to intonational meaning this paper has concentrated on main accents in sentences with narrow versus broad focus and on non-nuclear versus nuclear accents. The intonational realisation of other aspects of meaning in the interpretation of discourse has yet to be studied.

Another topic arising for future research is regional variation in Icelandic intonation. Previous research has shown that varieties of a language may differ with respect to the phonetic realisation of intonational categories (see e.g., Grabe, Post, Nolan & Farrar 2000 for a comparison of four varieties of English; Atterer & Ladd 2004 for two varieties of German). While Icelandic has relatively little dialectal variation in general (e.g., Pétursson 1978, Árnason 2005), there are regional features of the pronunciation of vowels and consonants (e.g., the 'hard' pronunciation of /p t k/, and the voiced pronunciation of /l m n/ before /p t k/ in northern varieties; see e.g., Haugen 1958; Árnason 1986). With respect to intonation, native speakers of Icelandic report that Northern Icelandic is overall 'more rising' than Southern Icelandic and

speakers from the north of Iceland tend to emphasise that their intonation is different from that of southeners. A systematic comparison of the two varieties will shed more light on these differences.

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NOTES

1. Final consonants in monosyllabic words are extrametrical. Vowels in monosyllabic words followed by one consonant are therefore long. See, for example, Árnason (1998b).
2. Exceptions to the rule that the first consonant in a cluster of two or more consonants between two vowels closes the first syllable are words that have intervocalic consonant clusters consisting of /p t k s/ followed by /v j r/. These clusters are syllabified as complex onsets of the second syllable, yielding an open first syllable (see (i) below; see Pétursson 1978:59 and Árnason 1980:22 for more examples).
   (i) *Open first syllable and consonant cluster as onset of second syllable* (from Árnason 1998b:15)
      a. nepja [nɪɛː.pʰja] ‘cold weather’
      b. tvisvar [tʰvɪː.svar] ‘twice’
3. As noted by Atterer & Ladd (2004:184), nasals are particularly clearly identifiable from the spectrogram ‘because of the spectral discontinuity at the moment of closure and the moment of release of the oral closure for the nasals’.
4. A reviewer notes that it might not be meaningful to distinguish between narrow and broad focus in final position. Indeed, it has been shown for other languages that broad focus and final narrow focus do not trigger different intonation patterns. However, for Icelandic, the potential difference between the two has not been conclusively studied. In fact, it is the results of the present experiments which suggest that final nuclear accents in broad and narrow focus contexts are not distinct in Icelandic.
5. The segmental label C2p was subsequently ignored in the analysis. It was present only on some prepositions preceding target words, specifically *til* ‘to’ (e001, e003), *me*ð ‘with’ (e008, e010, e011, e012) and *vi*ð ‘with’ (e006), but not *frá* ‘from’ (e002, e004, e005)

and *í* 'in' (e007, e009). The prepositions *me*ð and *vi*ð end in a voiced fricative which, in connected speech, is often only weakly articulated and has 'a tendency to disappear' (Árnason 2005:1562). This is exactly what was found in the present data.

6. Overall, eleven variables have been analysed, but some results were either inconclusive (as e.g., for L2) or unnecessary in the sense that they did not provide additional insights. They are thus not listed here. For discussion of which landmarks to choose for characterising F0 alignment, see much previous work on alignment, e.g., Silverman & Pierrehumbert (1990), Prieto et al. (1995), Atterer & Ladd (2004) and Schepman et al. (2006).
7. Note incidentally that final shortening was found for varieties of Danish, Bornholm in particular (see, e.g., Grønnum Thorsen 1988:130–133; Grønnum 1990), but in the Danish data it is the post-tonic that is shortened most (Grønnum Thorsen 1988:132). Future research may reveal if the findings are related.
8. Segment durations are schematised here because the most relevant segments, Vt in particular, differ significantly across conditions (see sections 2.1.5 and 2.2.5). For diagrams including segment duration, the reader is therefore referred to Figures 2, 3, 5 and 6 in this paper. It is the aim of Figure 8 to provide a summary of the two experiments and all conditions tested.
9. A reviewer notes that the alignment differences for H found between open and closed syllables might be accountable for in terms of real time distance between L1 and H such that the rises have a fixed duration. On the basis of the present data, the idea of fixed duration cannot be evaluated, but primarily because the experimental data were not designed to address the debate between segmental anchoring and fixed timing (see e.g., Ladd 2008:172–180).
10. Dehé (2009) provides some phonetic evidence. However, the data she used were from an experiment whose original purpose was not to study intonational categories.

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