

The perceptual importance of falling pitch for speakers from different dialects of Swedish

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Abstract

Falling pitch has long been argued to be a key feature in the distinction of Swedish pitch accents. In this paper, neurophysiological evidence substantiating the perceptual importance of HL pitch contours at the word level is discussed. When presented with novel words, Swedes across different dialect areas preattentively distinguished meaningful words with falling pitch. The preattentive response to meaningful HL contours in foreign words was likely based on transfer from the native tongue, thus providing evidence for the importance of falling pitch in the discrimination of word accents in four Swedish dialect areas. However, while falls appear to hold a key function in all dialect groups, additional dialect-dependent pitch patterns emerged that also affected preattentive word discrimination.

Introduction

Swedish has two pitch accents, accent 1 and accent 2, which are realised on word stems and affected by affixes (cf. Riad, 1998). Their pitch patterns differ systematically between dialects. Five dialect areas are distinguished in this respect: type 0, type 1A and 1B, and type 2A and 2B (cf. Gårding, 1973). Type 0 does not differentiate accent 1 and 2. The remaining dialect types are originally named with respect to the number of peaks that accent 2 receives in citation form (or focal position). Thus, type 1A and 1B have single peaks for both accent 1 and accent 2 while type 2A and 2B have one peak for accent 1 but two peaks for accent 2 (see *Figure 1*). The peak for accent 1 in type 2 dialects and second peak for accent 2, however, emerge only when the word accent HL contour is combined with subsequent focus-related high pitch. Breaking with the original labelling tradition, a third word accent type is tentatively included for Gothenburg Swedish: type 3. Here, accent 1 and 2 have both been shown to elicit double peak contours regardless of focus (e.g., Segerup, 2005).

Word accent clearly differ within dialects, on the one hand, and between dialects, on the other. Yet, it is often argued that this variability is entirely based on timing differences and that all word accents are essentially different encodings of an underlying HL contour (e.g., Bruce, 1983, 2005; Bruce & Gårding, 1978). Thus, regardless of dialect, the onset of the word accent fall is

earlier for accent 1 than for accent 2. Besides this crucial difference distinguishing the two word accents, there are further timing differences that distinguish the different dialect types. Thus, the onset of the word accent falls is earlier in type 2 dialects than in type 1 dialects. In type 2 dialects, the HL onset is in fact so early that accent 1 is realised as a low tone ([H]*L). The late onset in type 1 varieties, on the other hand, typically enforces the inclusion of a pitch rise from the previous word's L ([L]*HL). Regarding the A- and B-subtypes within type 1 and type 2, A has an earlier fall than B (Bruce, 1983, 2005). For the Gothenburg word accents, it is not quite clear how the timing relates to that of the other dialect types.

While the HL contour is likely the underlying feature that drives the word accent distinction within and between dialects, the vastly different realisations invite for speculations about the factual perceptual relevance of the fall in Swedish speakers. It is not necessarily certain whether the fall is equally important in all dialects. It is conceivable, for example, that listeners from type 2 dialect areas would perceive the difference between word accents as a high – low contrast or that speakers of type 1 dialects would make use of the rising part of the contour to distinguish words, as the remnant rise precedes the H*L.

A reliable way of investigating the perceptual importance of pitch patterns in a given population is to present its speakers with a foreign tone system and study acquisition of and interaction with the new tones. Acquired perceptual strate-

gies for the native language (i.e., specialised neural circuits) involuntarily guide the processing of foreign language input, at least initially. Swedish has recently received some attention in this context where it has been shown that Swedish speakers outperform speakers from non-tonal languages in the discrimination or processing of foreign tones (e.g., Burnham et al., 2014; Gosselke Berthelsen, et al., 2020). Interestingly, this is the case when tones are embedded in a linguistic context but does not hold for musical tones.

More closely investigating not simply the advantage of having tones in the native language (L1) but looking at specific pitch patterns, it has further been illustrated that Swedish second language (L2) learners highly accurately identify falling L2 tones (Gao, 2016, 2019). Accuracies for L2 fall-rising tones are also high. It is not certain whether the latter is due to the presence of the initial fall or related to the fact that the fall-rise contour is reminiscent of the combined pattern for word accent and focus tone (in some varieties). Importantly, high and rising L2 tones are recognised with considerably lower accuracy.

This behavioural advantage for falling tones, however, seems to disappear with high intensity training (Gosselke Berthelsen et al., 2021). Under such circumstances, Swedish native speakers did not perform differently in the detection of mismatches related to falls compared to rises and high or low tones. In fact, their behavioural responses were statistically indistinguishable from those of non-tonal participants. Yet, while the behavioural measures were not indicative of a perceptual advantage for falls, a fall-facilitated neurophysiological response was observed just 50 milliseconds after the onset of the tone. This relatively newly discovered response has been associated with a lexical gating process, distinguishing words from nonwords and grammatical from ungrammatical forms (e.g., Herrmann et al., 2009; MacGregor et al., 2012; Shtyrov & Lenzen, 2017). A reduction in this EEG component, argued to be related to eased preconscious processing, was found for falls in meaningful words. This suggests that Swedish listeners are conditioned from their L1 to automatically use falling pitch as a cue to lexicality status. A process, that they pre-consciously make use of even in the perception of foreign tones in a meaningful linguistic context.

Somewhat surprisingly maybe, none of the presented studies on Swedish native speakers' identification and processing of foreign tone offer clear information about the participants' dialectal background. Instead, they choose to treat Swedes

as a uniform group with respect to word-level pitch experience. A choice that is presumably seen as justified by the suggestion that all word accent realisations are instantiations of HL contours. However, the differences in pitch realisations at the word level as a result of timing differences and interactions with sentence-level pitch (e.g., focus tones) might in fact result in differences in perceptual cues for word discrimination in the different dialects. The present paper presents a first piloting attempt at bridging this gap and investigating if there are dialectal differences with regards to perceptually important pitch patterns. For this purpose, it will divide the neurophysiological data from Gosselke Berthelsen et al. (2021) according to the participants' native dialect and discuss emerging patterns for the lexical gating effect.

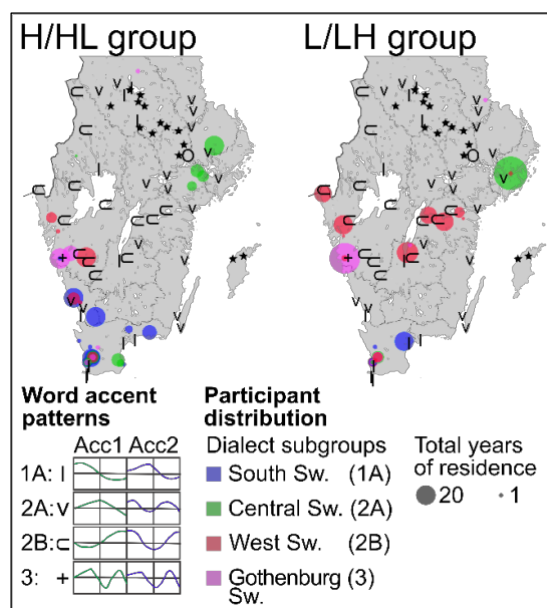
Methods

Participants

Twenty-three right-handed participants (aged 19-29, $M = 23.7$; 12 female) were informants in the present study. They were all native speakers of Swedish and came from three different dialect areas: South Swedish (type 1A), Central Swedish (type 2A, referred to by Bruce (e.g., 2005) as East Swedish), and West Swedish (type 2B). West Swedish was further separated into West Swedish and Gothenburg Swedish (type 3). Participants' dialects were determined in accordance with self-reported native dialect and primary area of residence, *Figure 1*.

Note that participants moved within and across dialect borders (number of moves = 1-6; $M = 2.8$), including a move to the Lund area in the south of Sweden, where all participants were residing at the time of testing.

Figure 1. Maps for both groups indicating subgroups, residence, and Swedish word accent patterns. Adapted from Gårding & Lindblad (1973), including Segerup (2005).



Participants were divided into two groups. They were tasked with learning novel foreign words with H* and H*L tones (H/HL group) or L* and L*H tones (L/LH group), respectively. Groups were matched for age ($M_{H/HL} = 23.4$ years; $M_{L/LH} = 24.0$ years) gender (H/HL: 6 female; L/LH: 6 female), and a large number of other background factors, such as working memory and socioeconomic status. Both learner groups could be divided into four subgroups representing the four dialectal areas, see Table 1.

Table 1. Number of participants per dialect.

Dialect	H/HL	L/LH
South Swedish	4	1
Central Swedish	3	3
West Swedish	2	5
Gothenburg Swedish	2	3

Materials

Twenty-four auditory, monosyllabic pseudowords were created for the experiment, Table 2. Although Swedish does not have differential pitch on monosyllables (they uniformly bear accent 1, e.g., *bil*₁, ‘car’), monosyllables were deemed suitable for this investigation as the pitch accent on a monosyllabic stem is systematically altered when suffixes are added (e.g., *bil*₂-ar, ‘cars’, *bil*₂-bälte, ‘seatbelt’, but *bil*₁-en, ‘the car’, cf. Riad, 1998). In the present stimuli, rather than adding pitch-

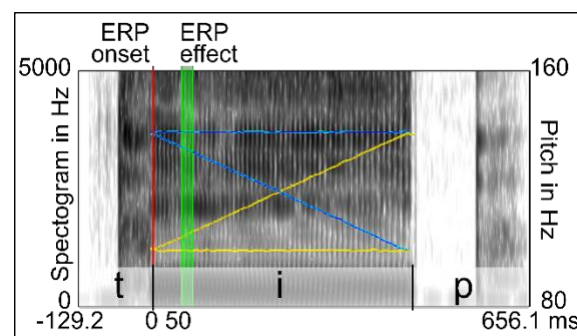
altering suffixes, the tones themselves served as grammatical suprafixes, see procedure below.

Table 2. Pseudowords used in the experiment.

i/u word pairs	a/ε word pairs
dif / duf	dap / dεp
fif / fuf	fap / fεp
kip / kup	kaf / kεf
lir / lur	lap / lεp
sis / sus	sap / sεp
tip / tup	taf / tεf

Half of the auditory stimuli were presented as novel words while the other half were presented as nonwords. A pseudoword learning paradigm was selected in order to guarantee equal exposure to the foreign words in which lexicality effects were to be studied. Word division was pseudorandom, such that i/u word pairs and a/ε word pairs were used as novel words or nonwords in an equal number of participants. In Praat (Boersma, 2001), four tones (H*, H*L, L*, L*H, see Figure 2) were added to the words in the following way: For any given participant, H*/H*L pitch would either be added to the novel words, assigning the participant to the H/HL group, or with nonwords, assigning the participant to the L/LH group. The L*/L*H would then be added to the other set of words: nonwords or novel words, respectively.

Figure 2. Spectrogram for example word /ti:p/ with the four pitch contours (H*, H*L, L*, L*H).



Procedure

Participants were presented with all words a total of 60 times, i.e. 30 times each on two consecutive days. All novel words were always followed by pictures of people in different professions to assign meaning to the words. The tones were associated with grammatical meaning, such that the difference between H* and H*L in the H/HL group or L* and L*H in the L/LH group would either be associated with grammatical gender or number distinctions (i.e., singular vs plural or

feminine vs masculine). This was done to assimilate the function of pitch on Swedish words while keeping an easily controllable, monosyllabic word structure. Participants were told explicitly that the words that they would learn would contain gender and number markers. To uphold the participants' attention and to assess learning progress, in some trials (12.5%), the novel words were presented with a wrong picture. Participants were prompted to indicate incorrectly matched trials by a button press.

Electroencephalography

During the experiment, EEG data was recorded from 64 Ag-AgCl EEG electrodes (EASYPAC GmbH, Herrsching, Germany) with a SynAmps2 amplifier and Curry Neuroimaging Suite 7 software (Compumedics Neuroscan, Victoria, Australia). Two bipolar eye channels (EOG) were included. Left mastoid (M1) served as online reference and AFz as ground. Sampling rate was set to 500 Hz and a low pass filter of 200 Hz was run online. Offline, the data was filtered with a 0.01 Hz high pass and a 30 Hz low pass filter. Epochs of 1200 ms were extracted at vowel/tone onset (cf. Figure 2) including a 200-ms baseline. Eye artefacts were corrected through independent component analysis (ICA, Jung et al., 2000). Epochs exceeding $\pm 100 \mu\text{V}$ were excluded ($M = 1.09\%$; $SD = 0.72$).

Preliminary results

To investigate the potential effect of dialect in the dataset, effect amplitudes for the significant electrode cluster (FC2, FC4, C1, Cz, C2, CP1, CPz, and CP2) and time window (50-70 ms) from Gosselke Berthelsen et al., (2021) were separated into dialects, see Table 3. Mean amplitudes showed a reduced effect for H*L tones when they were part of meaningful new words (H/HL group) regardless of dialect ($M = -0.76 \mu\text{V}$). This reduction emerged in comparison to both nonwords ($M_{L^*H} = -1.04 \mu\text{V}$; $M_{L^*} = -0.88 \mu\text{V}$) and novel words with H* pitch ($M = -0.86 \mu\text{V}$). When presented as part of nonwords (L/LH group), the H*L tone ($M = -1.06 \mu\text{V}$) was not preattentively differentiated from the other tones (novel words: $M_{L^*H} = -0.98 \mu\text{V}$; $M_{L^*} = -1.00 \mu\text{V}$; nonwords: $M_{H^*} = -1.06 \mu\text{V}$). The L/LH group instead showed a tendency towards a global amplitude reduction for novel words ($M = -0.99 \mu\text{V}$) compared to nonwords ($M = -1.06 \mu\text{V}$). For Central Swedish speakers (type 2A), in addition to the reduced amplitude for the fall in novel

words, there was also a noticeable amplitude reduction for L* and H* tones on novel words.

Table 3. Average amplitude in (μV) of all cluster electrodes in the 50-70 ms time-window for all dialect sub-groups by group and pitch pattern.

HL/H group Dialect	Words		Nonwords	
	H*L	H*	L*H	L*
South	-1.05	-1.19	-1.15	-1.16
Central	-0.17	-0.19	-0.82	-0.64
West	-0.98	-1.06	-1.25	-1.02
Gothenburg	-0.83	-1.00	-0.95	-0.71
LH/L group Dialect	Words		Nonwords	
	L*H	L*	H*L	H*
South	-0.81	-0.90	-0.78	-0.88
Central	-0.92	-0.79	-1.09	-1.07
West	-1.55	-1.57	-1.70	-1.66
Gothenburg	-0.65	-0.74	-0.67	-0.62

Discussion

The results presented here emphasise the suggested special status of the falling tone at word level for Swedish listeners. When H*L pitch is present in a meaningful word, the early EEG component related to lexical gating is reduced. The reduction, which is argued to be related to ease of processing, was uniformly found in listeners from all four dialect areas in the current study. This demonstrates the perceptual importance of pitch falls at the word level in Swedish regardless of dialect, strengthening the claim that it is indeed the fall that primarily distinguishes word accents regardless of their realisation in the complex interplay with timing and sentence-level pitch (e.g., Bruce, 1983, 2005; Bruce & Gårding, 1978).

Given its close relation with word stems and affixes in Swedish, it is not surprising that the H*L tone could only serve as a cue for lexicality judgements when it was added to meaningful words. When it had no meaning or function, it was too dissimilar from the native tones to affect L2 processing. Thus, in conditions where L* and L*H were associated with novel words, a tone-independent but substantially smaller effect of lexicality was observed. It is likely, that listeners less successfully learned to use other differences in the speech input (i.e., L* and L*H tones or vowels) in absence of an H*L cue.

An intriguing pattern was observed for the Central Swedish subgroups. In addition to the amplitude reduction for falls, they also showed a reduced amplitude for high and low tones when these were part of meaningful words. Central

Swedish (type 2A) is argued to have the earliest fall onset both for accent 1 and accent 2 (cf. Bruce, 1983). As such, accent 1 is realised as a low tone ([H]*L) in pre-focal position and for accent 2, the high tone is prominently associated with the stressed syllable (*HL). The preliminary results presented here indicate that the timing of the fall contour in Central Swedish has an impact on the perceptual prominence of pitch for native speakers of this dialect. To this effect, Central Swedish speakers pre-consciously use the pitch fall as well as low and high level tones as perceptual cues for lexical distinction. Thus, response amplitudes for the early EEG component are reduced for all three pitch types, indicating eased processing due to transfer from the native dialect. Interestingly, the same pattern is not observed in the type 2B dialect. The relatively later onset of the word accent fall in this variety likely diminishes its potential perceptual interpretation as a low tone.

The 1B dialect type was not included in the present investigation due to lack of participants. However, its relative similarity with 1A word accent patterns tentatively suggests that the fall would have the same status as it does in the remaining dialects. However, it is of course possible that there are additional perceptual cues. As the dialect area with the latest onset for the word accent falls, the type 1B variety has the longest rise leading up to the H of the HL contour. Hence, rises potentially play a slightly larger role in this dialect than in the others.

Not mentioned explicitly in the introduction, the two previous studies on Swedish learners identification of L2 tones carried out by Gao (i.e., Gao 2016, 2019) find slightly different results with respect to the two very accurate patterns (fall vs fall-rise). In one study (2019) the fall is the most accurate pattern while in the other (2016), the fall-rise is slightly more accurate than the fall. In light of the present results, one possible explanation for this minor difference might be the participants' dialect background. It is possible, and indeed to some degree indicated in the paper, that the 2016 study had a large number of participants from type 2B varieties where, in focal position, accent 1 is realised as a fall-rise and accent 2 has a double peak pattern (see *Figure 1*). This might lead to high fall-rise accuracy. The 2019 study, on the other hand, might have been conducted with a larger number of participants from type 1 varieties who are not familiar with double peak word accents from their native dialect, leading to the expected higher accuracy for the fall.

In sum, the current pilot study into the role of dialectal variation for the perceptual salience of pitch cues at the word level found that falling tones on meaningful words boosted pre-conscious lexicality judgments throughout all the four tested dialectal areas and possibly beyond. The neurophysiological results emphasise the key function that falling pitch plays in Swedish speakers' word perception overall. Yet, native dialect pitch timings can affect perceptual salience and potentially sensitise listeners to additional pitch cues. Thus, while the fall is arguably the most important perceptual cue for speakers of all tonal dialects of Swedish, care should be taken when treating Swedes from different dialect backgrounds as a uniform group with respect to word-level pitch processing. More extensive data, possibly including a larger variety pitch contours, is needed to corroborate the present findings.

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