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EXOTIC VOWELS IN SWEDISH – AN ARTICULOGRAPHIC AND ACOUSTIC PILOT STUDY OF /iː/

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ABSTRACT

This paper describes an articulographic and acoustic pilot study of the realisation of the vowel /iː/ in two regional varieties of Swedish. The study was carried out within the new research project *Exotic vowels in Swedish – an articulographic study of palatal vowels [VOKART]*, which aims at increasing the empirical knowledge of vowel production in general, and extending our knowledge of the articulatory dynamics of palatal vowels in Swedish in particular. Articulatory and acoustic recordings of two male speakers – one South Swedish with regular [iː] and one East Central (Standard) Swedish with "damped", so called "Viby-coloured" [ɨː] – were analysed. Results showed that [ɨː] was pronounced further back with an overall lower tongue position, but with a higher position of the tongue tip than [iː]. Acoustic analysis showed a lower F_2 for [ɨː] than [iː], indicating a more centralised vowel quality. These very tentative results will be followed up with larger studies within the project.

Keywords: Swedish vowels, Swedish dialects, Vowel articulation, Articulography, Viby-/iː/.

1. GENERAL INTRODUCTION

In a cross-language comparison, Swedish has a fairly rich vowel system, and Swedish vowels have some particularly unusual and distinctive features. One such exotic feature is that among the front, close vowels there are three contrastive long vowel sounds /iː, yː, ʉ̟ː/, characterised by a relatively small acoustic and perceptual distance, exemplified by minimal triplets such as ni, ny, nu /niː, nyː, nʉ̟ː/ ('you', 'new', 'now'). For these three vowel sounds, the tongue articulation is assumed to be basically identical, but the documentation of this is incomplete, including the articulatory dynamics. Specifically the contrast between /yː/ and /ʉ̟ː/, two similar but still phonemically distinct rounded vowels, is considered highly unusual and exotic among the world's languages. The acquisition of these two vowel sounds by Swedish children as well as adults learning Swedish typically presents a major difficulty [e.g., 9, 13].

Yet another exotic feature is the nowadays fairly wide-spread realisation of /iː/ and /yː/ in Swedish with a "damped", "buzzing" so called "Viby-coloured" (named after the small town of Viby in Central Sweden) quality, generally phonetically transcribed as [ɨː]. This vowel quality has been recognised as a dialectal feature in several Swedish regions [5], and is considered to be very rare among the world's languages [12].

Phonetic investigations of vowels in different languages have been mainly acoustic [11]. Acoustic studies of Swedish vowels using formant frequencies include Fant [8], Eklund and Traunmüller [6], and Kuronen [10]. However, it does not seem possible to uniquely determine the underlying articulation of a vowel from acoustic measurements of its formant frequencies.

The purpose of the new research project is to use articulography to analyse and understand the articulation of palatal vowels in Swedish in order to increase the empirical knowledge of vowel production in general, and to extend our knowledge of the articulatory dynamics of these vowels in particular.

2. OBJECT OF STUDY AND GOALS

The general object of study of the project is the production of vowels, specifically the articulation of the Swedish long palatal vowels /iː/, /yː/, /ʉ̟ː/, /eː/ and /øː/. We will focus on three specific issues: (1) the crowding of vowels among the front, close vowels, particularly /yː/ and /ʉ̟ː/, (2) the diphthongisation of all five, long vowels, and (3) the special realisation of /iː/ and /yː/ vowels with a "damped" quality in contrast to the regular realisation of these vowel sounds.

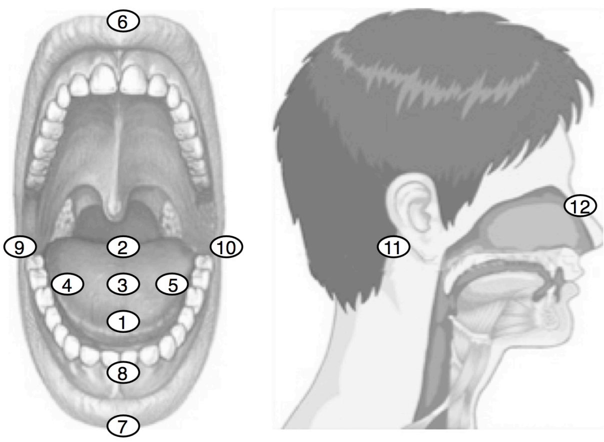
The major goal of our project is to describe and understand the articulation of Swedish palatal vowels, including their articulatory dynamics (diphthongisation). Furthermore, we will also elucidate the dialectal variation among Swedish vowels. For this purpose, we will restrict ourselves to studying vowels produced by speakers from the three metropolitan areas of Stockholm, Göteborg and Malmö, which represent East Central (Standard), West Central and South Swedish.

3. MATERIAL AND METHOD

Speech material containing vowels from at least 15 subjects from each of the three dialectal areas Stockholm, Göteborg and Malmö will be recorded. For the sake of completeness, we are planning to record realisations of all Swedish vowel phonemes. We will then focus our study on the palatal vowels. Articulographic and acoustic recordings of the vowels will be made in several consonantal contexts and different types of speech material. The recorded movements of each vowel will then be analysed using automatic methods. As indicated above, our focus will be on articulation, but also the formant frequencies (F_1, F_2, F_3) and their dynamics (possible diphthongisation) will be analysed and related to the articulatory trajectories.

We will use the Carstens Articulograph AG500 to record the articulatory movements. This method is based on the principle that when a coil (sensor) moves inside a magnetic field, a voltage is induced in the coil, which is proportional to the distance between the coil and the transmitter coil generating the magnetic field. Articulography tracks movements in 3D of the discrete points where the sensors are attached to the tongue or to other articulators. We will record twelve sensors simultaneously. Figure 1 shows the placement of these.

Figure 1: Positions of the twelve sensors in the experiment set-up.



Our articulographic method is particularly suited for examining the assumed similarity in tongue position among the Swedish close front vowels. The magnitude of the lip opening (from larger to smaller) is regarded as the major distinctive feature for these vowels: unrounded (with spread lips) /iː/, outrounded /yː/, and inrounded /ʉ̟ː/ [8, 12].

4. PILOT STUDY OF TWO REALISATIONS OF /iː/ IN SWEDISH

Our interest in studying the damped realisation of /iː/ and /yː/ from a production point of view is related specifically to an old dispute represented in the Swedish linguistics and phonetics literature about its precise place of articulation [4]. The disagreement is about whether the point of major constriction for these vowel sounds, i.e. damped /iː/ and /yː/, is further front, as compared to their regular counterparts (front, close vowels), and basically alveolar [14], or instead further back and rather central [3]. Moreover, the position of the tongue tip relative to the tongue dorsum in damped /iː/ and /yː/ has also been under debate [see e.g., 7]. It should be stressed that these views about the specific point of major constriction of these vowels are at best intelligent speculations, as adequate articulatory data seem to be lacking here. A fronted (alveolar) variant would seem to be more odd as a place of articulation of a vowel, while a retracted (central) variant would appear to be a vowel articulation which is less unusual and found in a fair number of the world's languages [1, 7]. To learn more about the articulation and acoustics of the regular and damped realisations of Swedish /iː/, we conducted a small articulographic and acoustic pilot study.

4.1. Data and Method

Articulographic and acoustic recordings of /iː/ with two Swedish male speakers of different regional varieties – one South Swedish speaker with regular [iː] and one East Central Swedish speaker with damped [ɨː] – were made using the Carstens Articulograph AG500. Three repetitions of the two words /biːbel/ and /papiːpa/ with bilabial contexts and primary stress on the /iː/ vowel were recorded using a subset of the numbered sensor positions shown in Figure 1. Sensors were placed on the tongue tip (1), tongue blade (3) and tongue dorsum (2). As reference points we placed sensors on the nose bridge (12) and behind the ear (11).

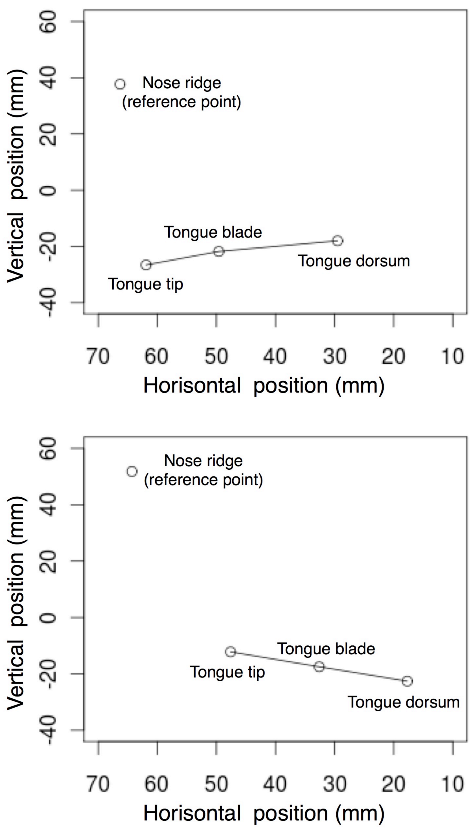
Articulographic analysis was done using the MATLAB script Mview [15], while the acoustic analysis was made with Praat [2].

4.2. Results

4.2.1. Articulographic analysis

The MATLAB script Mview enables examination of the data in three dimensions. Since the recorded sensors were aligned along the tongue on the same axis, we focussed on the tongue movement pattern at a midsagittal plane. As an example illustration we selected an articulatory measurement sample of the steady-state portion of each vowel. We only analysed a single point in time since we mainly wanted to study the articulatory difference between two acoustic realisations (phones) of [iː] and [ɨː]. The dynamic properties (diphthongisation) are thus not examined here. Figure 2 shows the positions of the sensors during this time instant.

Figure 2: Midsagittal plots of four articulatory measurement sample points from a single point in time of the steady-state portion in Swedish regular [iː] (top) and damped [ɨː] (bottom).



The tongue appears to be positioned more forward in the mouth (relative to the nose bridge) for [iː] than for [ɨː]. Another difference is that for [iː] the tongue blade is lower than the tongue dorsum and the tongue tip is lower than any of the other two. For [ɨː], however, the height pattern is reversed; the tongue tip appears to be higher than the blade and dorsum. The overall position of the tongue also appear somewhat lower (again, relative to the nose bridge) for damped [ɨː].

4.2.2. Acoustic analysis

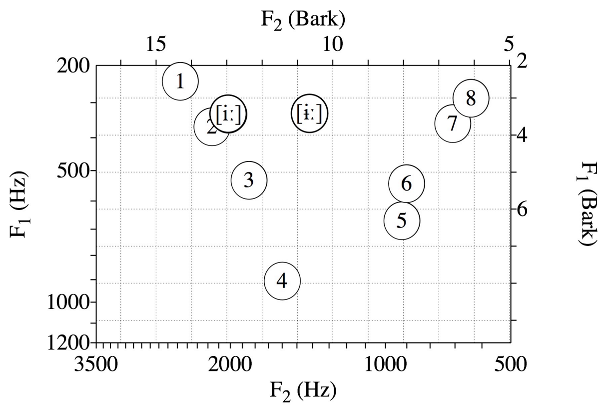
Table 1 displays the mean values of the first four formant frequencies (F_1-F_4) of manually segmented steady-state portions of three repetitions each of regular [iː] and damped [ɨː]. F_1 appears to be almost identical in [iː] and [ɨː], while F_2 is 601 Hz higher in [iː]. F_3 and F_4 show slight differences; F_3 is 131 Hz higher in [iː], while F_4 is 282 Hz higher in [ɨː].

Table 1: Mean formant frequencies (Hz) of the first four formants in the steady-state portion of [iː] and [ɨː] (three repetitions by one male speaker for each vowel realisation).

Mean F_n (Hz)	[iː]	[ɨː]
F_1	332	330
F_2	2017	1416
F_3	2685	2554
F_4	3239	3521

Figure 3 shows an F_1/F_2 plot with one Bark circles of regular [iː] and damped [ɨː] as well as of the primary cardinal vowels pronounced by Daniel Jones [see e.g., 16]. [iː] appears to be quite similar to the second primary cardinal vowel [eː], i.e. a front close or close-mid vowel, while [ɨː] is positioned further back, like a central close or close-mid vowel.

Figure 3: F_1/F_2 plot of mean formant values measured in the steady-states of regular [iː], damped [ɨː], and the eight primary cardinal vowels as pronounced by Daniel Jones. Each circle is one Bark in diameter.



4.3. Discussion

Articulatory as well as acoustic differences between regular and damped /iː/ were observed. We found a difference in tongue position that suggests that [ɨː] is pronounced further back, i.e. not as an alveolar, but more like a central palatal vowel. The shape of the tongue is also different in the two realisations, i.e. an downward slope from dorsum to tip for [iː], but an upward slope for [ɨː]. This supports the observations of [ɨː] by Noreen [14], but not Borgström [3]. However, the tongue position and shape needs to be investigated further using more subjects of several Swedish dialects, since it is a well known fact that different articulatory settings can generate almost identical acoustic features.

The acoustic analysis showed that the formant frequencies differ mainly in F_2, indicating that the main difference between the two realisations is that [ɨː] is pronounced further back than [iː]. This is in line with Engstrand et al. [7]. Both [iː] and [ɨː] seem closer to the second cardinal vowel [eː] than the first [iː], suggesting that they are close-mid vowels. However, the South Swedish speaker used a slight diphthongisation [eiː], and although only the steady-state portion of the [iː] was used in the pilot study analysis, this may still have had some influence on the results.

Our tentative results are based on a very limited material from two speakers. They need to be followed up with a larger study with more subjects and vowel repetitions. Future work includes recording and analysing all Swedish vowel phonemes produced by at least 15 subjects each of the three dialectal areas in a larger number of consonantal contexts.

5. ACKNOWLEDGEMENTS

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