Exotic vowels in Swedish: a project description and an articulographic and acoustic pilot study of /i:/

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Exotic vowels in Swedish: a project description and an articulographic and acoustic pilot study of /iː/

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Abstract

This paper introduces the 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 at extending our knowledge of the articulatory dynamics of palatal vowels in Swedish in particular. In a pilot study of the realisation of the vowel /iː/, we analysed articulatory and acoustic recordings of two male speakers of different regional varieties of Swedish– one South Swedish with regular [iː] and one East Central (Standard) Swedish with "damped" so called "Viby-coloured" [ɨː]. Results showed that [ɨː] was pronounced further back with an overall lower tongue position, but with a higher tongue tip position than [iː]. Acoustic analysis showed a lower* F_2 *for [ɨː] than [iː], indicating a more centralised vowel quality. These tentative results will be followed up with larger studies. In addition, one of the analysis tools being developed within the project is described briefly.*

General introduction

In a cross-language comparison, Swedish has a fairly rich vowel system with some particularly exotic and distinctive features. One such 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 /niː, nyː, nʉ̟ː/ ('you', 'new', 'now'). 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., Johansson, 1973; Linell and Jennische, 1980). For these three vowels, the tongue articulation is assumed to be basically identical, but the documentation is incomplete.

Yet another exotic feature is the today 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 (Bruce, 2010), and is considered to be very rare among the world's languages (Ladefoged and Maddieson, 1996).

Phonetic investigations of vowels in different languages have been mainly acoustic (Ladefoged, 2003). Acoustic studies of Swedish vowels using formant frequencies include Fant (1959), Eklund and Traunmüller (1997), and Kuronen (2000). However, it does not seem possible to uniquely determine the underlying articulation of a vowel from its formant frequencies.

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.

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 will record realisations of all Swedish vowel phonemes, and then focus our study on the palatal vowels. Articulographic and acoustic (16 kHz/16 bit) 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 (at 200 Hz). 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 positions of these.

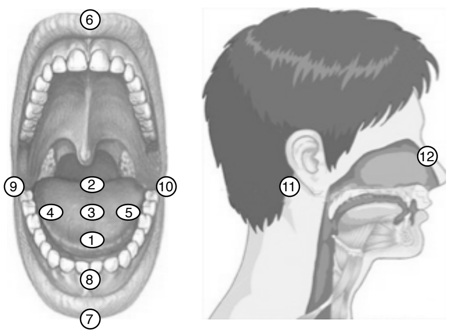

Figure 1: Positions of the 12 sensors to be used.

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/ (Fant, 1959; Ladefoged and Maddieson, 1996).

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 (Bruce and Engstrand, 2006). 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 (Noreen, 1903), or instead further back and rather central (Borgström, 1913). 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., Engstrand et al., 2000). 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 (Björsten et al., 1999; Engstrand et al., 2000). To learn more about the articulation and acoustics of the regular and damped realisations of Swedish /iː/, we conducted a small pilot study.

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 [iː] – 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 sensor positions shown in Figure 1. Sensors were placed on the tongue tip, tongue blade and tongue dorsum. We placed reference sensors on the nose bridge and behind the ear. Articulographic analysis was made with the MATLAB script Mview (Tiede, 2010), and Praat (Boersma and Weenink, 2011) was used in the the acoustic analysis.

Results

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 examined the tongue movement pattern at a midsagittal plane. We selected an articulatory measurement sample from one point in time from the steady-state portion of each vowel. Figure 4 shows the positions of the sensors at this time instant.

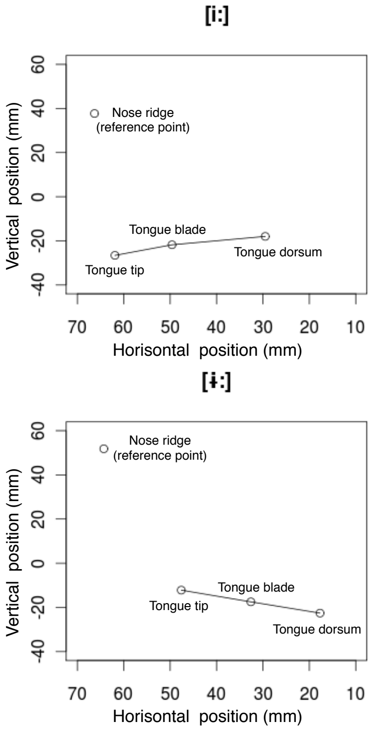

Figure 2: Midsagittal plots of four articulatory measurement sample points from one point in time of the steady-state portion of Swedish regular [iː] (top) and damped [ɨː] (bottom).

The tongue is 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 others. The overall position of the tongue also appear somewhat lower (again, relative to the nose bridge) for [ɨː].

Acoustic analysis

Table 1 displays 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].

Figure 3 shows an F_1/F_2 plot with one Bark circles of regular [iː] and damped [ɨː], as well as the primary cardinal vowels pronounced by Daniel Jones (see e.g., IPA, 1999). [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.

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

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).

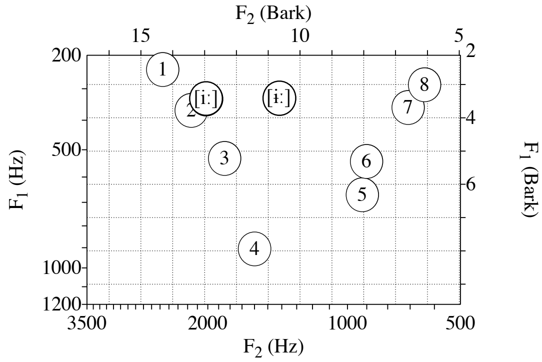

Figure 3: F_1/F_2 plot of mean formant values measured in the steady-states of regular [iː] and damped [ɨː] along with the eight primary cardinal vowels as pronounced by Daniel Jones. Each circle is one Bark in diameter.

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 (1903), but not Borgström (1913). However, the tongue position and shape needs to be investigated further using more subjects of several Swedish dialects.

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. (2000). Both [iː] and [ɨː] seem closer to the second cardinal vowel [eː] than the first one [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 analysis, this may still have had some influence on the results. Our tentative results are based on a very limited material and need to be followed up by larger studies with more subjects and vowel repetitions. Future work includes recording and analysing all Swedish vowels produced by at least 15 subjects each from three dialectal areas.

Exemplifying work in progress

We are currently developing tools for visualising the data. One way of plotting articulatory data is the common midsaggital view of the tongue from the side. Figure 4 shows an example of such a plot of the tongue profiles for one realisation of each of the Swedish long vowels /iː, yː, eː, øː, ɛː, ʉ̟ː, uː, oː, aː/ along with the palate contour for one speaker and one moment in time per vowel.

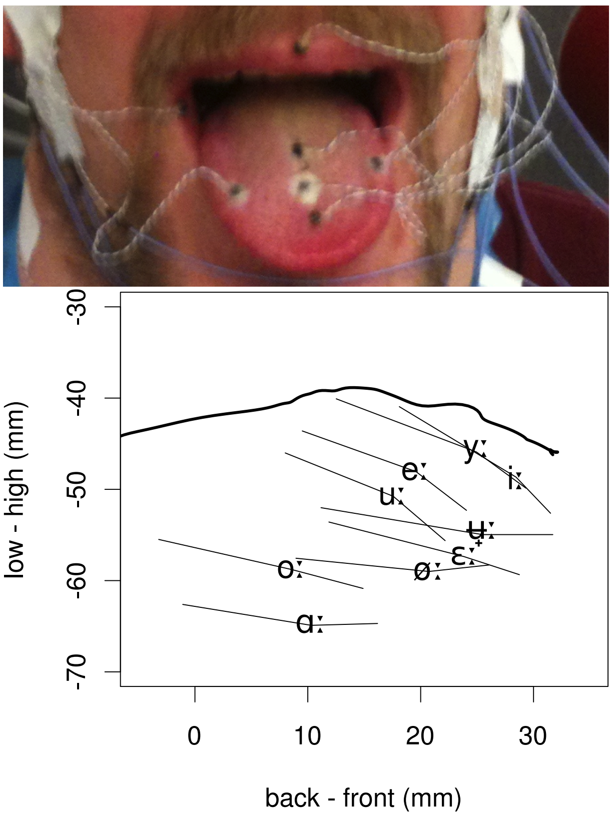

Figure 4: Sensors placed on a male south Swedish speaker and the corresponding midsagittal view of the palate contour and stylised tongue profile for one moment in time of the Swedish long vowels /iː, yː, eː, øː, ɛː, ʉ̟ː, uː, oː, aː/.

The palate profile was measured as the subject pressed the tongue tip sensor up against the palate and slowly pulled it backwards. The tongue profiles were reconstructed from sensors 1, 2 and 3 (see Figure 1) by simple linear interpolation. Future work includes developing visualisation tools for vowel dynamics in three dimensions.

Acknowledgements

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