SWEDISH 'DAMPED' /i/ AND /y/: EXPERIMENTAL AND TYPOLOGICAL OBSERVATIONS

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ABSTRACT

In scattered Swedish dialects, the vowels /i/ and /y/ are pronounced with a markedly low F_2. This results in a 'damped' vowel quality that appears to be rather unusual in a typological perspective. To date, however, no experimental studies of this vowel type have been carried out using Swedish material. In this paper, formant frequencies are presented for one dialect suggesting that the /i/ vs. /y/ contrast has been neutralized, and that the resulting vowel should be associated with unrounded high central [ɨ]. This hypothesis was corroborated by an articulatory simulation. It is thus suggested that the damped vowels found in the Swedish dialects are members of a relatively common vowel type. This was further supported by preliminary perceptual evidence suggesting that Swedish listeners accept Turkish [ɨ] as an instance of the Swedish damped vowel and, conversely, that Turkish listeners accept this vowel as an instance of Turkish [ɨ].

1. INTRODUCTION

The phonetic study of the dialects has a long tradition in Sweden; it began well before the last turn of the century and was in full swing during the first few decades of this century. During this period, excellent phonetic descriptions of individual dialects or of dialectal variation within larger areas were written, and thousands of hours of field recordings were made.

On the other hand, traditional dialectology was a product of its time; in particular, analyses were largely prestructuralist and made without access to modern experimental techniques or a general phonetic-typological framework. Thus, whereas the collected documentation clearly shows that the Swedish dialects are extremely rich in phonetic and phonological variation, many patterns emerging from this variation were invisible at the time, and thus several phenomena had to be left unaccounted for. Today, however, modern phonetics faces the challenge to approach several longstanding problems from a new angle. The purpose of this paper is thus to demonstrate, by way of exemplification, that sound patterns found in the dialects can indeed be explained from a general phonetic and typological point of view.

The sound type to be examined is a 'damped' vowel type that corresponds to the /i/ and /y/ phonemes of standard Swedish. In the dialectological literature, this sound is usually known as 'Viby i' after the place in south-central Sweden, Viby, where it was first observed. However, this sound occurs in several scattered dialects, both in rural areas and in the city dialects of Stockholm and Göteborg (Gothenburg); in Stockholm, it is known as 'Lidingö i' [4, 5, 7, 10, 13, 14].

A controversial question in the traditional dialect literature concerned the articulatory description of the damped vowel type. It was considered apico-alveolar by at least one author [13], while others [1, 10] suggested that it was a back unrounded vowel. But at any rate, it was considered a quite marginal phonetic phenomenon. It would be unexpected, however, to find a typologically unusual vowel represented in several, geographically scattered dialects of one language. In contrast, then, it is hypothesized here that the damped vowel type observed in the Swedish dialects represents a more widely spread phonetic category. To check this possibility, this paper attempts to characterize this vowel from several angles; in particular, it reports *i*) measurements of formant frequencies, *ii*) an articulatory simulation experiment, *iii*) a typological profile based on the results of these test, and, finally, *iv*) a listening test designed to find out to what extent damped vowels are perceptually acceptable across languages.

2. ACOUSTIC CHARACTERISTICS

2.1. Speech material and method

The speech material consisted of an approximately 4 minutes long monologue produced by an elderly male speaker from a village (Kräklinge) near Viby. The recording comes from a collection of dialect recordings [6] extracted from the Swedish dialect archives. The material was digitized at 16 kHz, and the frequencies of the first four formants were measured from computer-generated broadband spectrograms of all lexically long vowels with a duration no less than 100 ms. A minimum duration was considered essential to prevent vowels from strongly assimilating to the consonant context [cf. 9].

2.2. Results

The measurement results are shown in Table 1 along with formant data for some relevant Central Standard Swedish vowels [3]. The following points can be noted in particular:

1) In terms of F_1 and especially F_2, the dialect's /i/ and /y/ are strongly centralized compared to standard Swedish.

2) In contrast to the standard Swedish data, the dialect's /i/ and /y/ display similar values for all four formants. A t test revealed no statistically significant difference between the dialect's /i/ and /y/ in any of the four formants ($p>0.5$). Also, the dialect's /i/ and /y/ sound very similar. Thus, it appears likely that the phonemic difference between the two vowels has been neutralized.

3) The dialect's /e/ shows a lower F_1 and a higher F_2 than standard Swedish /e/. Thus, it is acoustically closer to (and indeed sounds like) standard Swedish /i/. The dialect's /e/ has, as it were, replaced the missing high front unrounded /i/.

Do the observed formant data make it possible to identify this dialect's damped vowel with any known category? Yes, probably. It appears to be quite similar to the formant frequencies

Vowel		F$_1$			F$_2$			F$_3$			F$_4$	
	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Kräklinge i	350	52	22	1590	167	21	2860	145	20	3590	253	14
e	340	68	20	2220	174	20	2730	258	18	3670	251	14
ä	420	44	3	2040	76	3	2600	50	3	3480	111	3
y	310	40	5	1560	38	5	2720	53	5	3330	81	4
u	320	72	18	1490	270	14	2320	176	15	3330	105	13
ö	410	32	10	1580	135	10	2300	95	10	3300	72	9
o	280	43	6	560	76	5	-	-	0	-	-	0
å	410	73	26	870	215	22	2680	201	14	3370	168	12
a	570	59	23	970	107	19	2670	147	13	3350	120	13
Standard i	291	12	-	2107	74	-	3135	61	-	-	-	-
e	376	14	-	2152	41	-	2720	82	-	-	-	-
y	285	4	-	1988	61	-	2745	119	-	-	-	-

Table 1. Formant frequencies (F_1-F_4) in Hz for long vowels in the Kräklinge dialect, and some long vowels in Standard Swedish. The data for Standard Swedish are from [3]. The letters of the Swedish alphabet have been used to label the sounds. SD=Standard Deviation, N=Number of observations.

Vowel	TAE	TAP	JO	LH	TP	TS	LR	F$_1$	F$_2$	F$_3$
i, dorsal	-	-	7	85	-1.0	0.1	S	335	1647	2719
i, apical	10	0	8	85	-0.9	0.1	S	332	1552	2724
e	-	-	9	85	-0.7	0.9	S	349	2190	2700

Table 2. Result of Apex simulation: Articulatory parameter settings which generetes formant values (F_1-F_3) most closely corresponding to the front vowels in Table 1. TAE = Tongue Apex Elevation, TAP = Tongue Apex Protrusion, JO = Jaw Opening, LH = Larynx Height, TP = Tongue Position, TS = Tongue Shape, LR = Lip Rounding. Tongue Apex Elevation, Jaw Opening and Larynx Height are given in mm (Larynx Height relative to the highest point of the hard palate). Tongue Position is specified by a number from -1 (palatal) to 0 (velar) to +1 (pharyngal). Tongue Position specifies the deviation of the tongue from neutral position (0 = neutral, 1 = fully curved), S = spread lips, R = rounded lips.

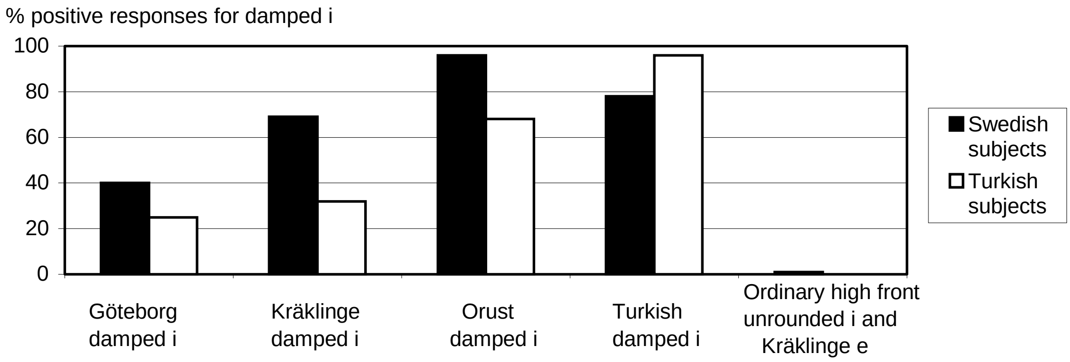

Figure 1. Percent stimuli of different categories identified as damped i by Swedish and Turkish listeners.

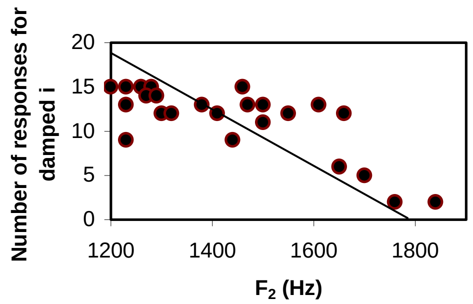

Figure 2. Correlation between number of identifications as damped i and formant 2 (F_2) for Swedish listeners. The line shows best fit according to the method of least squares.

found for high central unrounded vowels. For example, Catford's [2] F_1 and F_2 values for cardinal [ɨ] are very similar to the data presented here. This, then, suggests that the damped vowel type found in the Swedish dialects could be placed in a more general phonetic context. Can this be backed up by articulatory evidence?

There is no direct knowledge of the articulation of this vowel type. For the time being, therefore, a computer-implemented model of articulation (the 'APEX' model) has been used to carry out an articulatory simulation experiment.

3. ARTICULATORY SIMULATION

An articulatory simulation experiment was run using 'APEX', a computer-implemented model of speech production [15]. This model represents an attempt to describe the production of vowels and other speech sounds in a quantitative, physiologically realistic way. Articulatory configurations of the speech organs are specified in terms of 8 parameters such as 'Tongue Height' and 'Lip Rounding'. From this input, the model generates, on the one hand, an animated sequence of speech movements and, on the other hand, audible sounds.

In the present study, however, the model was run 'backwards' to calculate articulatory configurations from formant frequencies. The essential steps of this experiment are to 1) feed a set of observed formant frequencies to the model, 2) ask the model to produce a vowel with these formant frequencies, and 3) observe the articulatory configuration that produce the observed formant pattern most successfully. In other words, a matrix was constructed in which all 8 articulatory parameters were systematically varied, creating a large number of possible articulatory configurations. F_1-F_4 were calculated for each configuration. This gave an overview of the model's ability to create vowel sounds. Using the formant values of the dialect data, the articulatory configurations compatible with these values were extracted from the matrix. A deviation of 5% was tolerated in the formant frequencies.

The results for the vowels /i/ and /e/ are shown in table 2. The general shape of the tongue body is palatal and close to APEX' neutral tongue shape, i.e., centralized . It is also clear that the formant values of the dialect's damped vowels can be achieved both with and without apicalization, i.e., elevation of the tongue tip. Raising the tongue tip by 10 mm leads to a further lowering of F_2 (by approximately 100 Hz). From an auditory point of view, this would result in further damping and thus an increased contrast with the nearest high, unrounded, non-centralized vowel in the system. It is possible that this dimension is exploited to different degrees in different dialects. Thus, the dialectologists' question whether the damped vowel type is produced with or without apicalization could not be unambiguously settled - both possibilities still remain.

For the dialect's /y/, it was not possible to find a matching articulatory configuration on the assumption that it is produced with lip rounding, i.e., setting the 'Lip Rounding' parameter to 'rounded'. This suggested that /y/ is not produced with lip rounding in this dialect and supports the above conclusion that /i/ and /y/ are not phonemically distinct in this dialect.

4. TYPOLOGICAL PROFILE

The APEX simulation suggested that the IPA symbol [ɨ] should be used as an overall label for the damped vowel type found in the Swedish dialects. How common, then, is this sound in the languages of the world? To answer this question, the UPSID database was used. UPSID is an acronym for the UCLA Phonological Segment Inventory Database, a genetically balanced sample of segment inventories in 451 of the world's languages [11,12]. An analysis of UPSID showed that /ɨ/ occurs in 61 of the 451 languages (i.e., 14 percent). Table 3 indicates that the vowel type is fairly evenly distributed over the language

Language Stock	Number of Languages	Number of /ɨ/ Lgs.	%Languages with /ɨ/
Indo-Eur	23	3	13
Ural-Alt	28	2	7
Austro-As	14	2	14
Austro-Tai	39	6	15
Sino-Tib	21	2	10
Caucasian	7	2	29
Dravidian	6	0	0
Other Euras	7	1	14
Niger-Kord	55	3	5
Nilo-Sahar	23	1	4
Afro-Asiatic	26	4	15
Khoisan	4	0	0
Amer I (N)	58	6	10
Amer II (S)	66	23	35
Na-Dene	7	0	0
Eskimo-Ale	3	0	0
Australian	25	1	4
Papuan	39	5	13
UPSID	451	61	14

Table 3. Number of UPSID languages having /ɨ/.

stocks recognized by UPSID, but that there are also some strong areal tendencies; the South American languages, for example, show an unusually high incidence (35 percent) of the vowel type. It may thus be assumed that /ɨ/ has developed independently in several stocks, and that the Swedish situation, where /ɨ/ occurs in several widely separated dialects, might be a mirror image of this. A perception test has been conducted as a preliminary test of this hypothesis.

5. CROSS-LANGUAGE PERCEPTUAL EVALUATION

5.1. Introduction

Preliminary measurements suggest that in yet another Swedish [ɨ] dialect (Orust), F_2 may be even lower (approximately 1300 Hz) than observed in the present data. These values are similar to those found for the corresponding vowel in Turkish (our measurements); this sound is written as 'i without a dot' in Turkish orthography, the upper-case variant being 'ı'. On the other hand, other Swedish dialects' [ɨ] seem to have F_2 slightly higher (near 1700 Hz) than in the present data [14]. Do listeners tend to place these vowels in the same phonetic category in spite of the relatively wide F_2 range? That was the question addressed in the perception test described in this section.

5.2. Test design

15 native Swedish and 5 native Turkish listeners participated in the test. The stimuli were [ɨ] segments from 3 Swedish dialects (Kräklinge, Orust and Göteborg) with one speaker from each dialect) and from Turkish (3 speakers). The Turkish speakers also produced instances of regular high front unrounded [i], and the Kräklinge speaker also produced instances of [e] (which, as noted, sounds much like standard Swedish [i]); in addition, instances of standard Swedish and Polish [i] were used. The Swedish and Polish vowel stimuli were excised from readings of word lists or conversational speech, whereas the Turkish stimuli were vowels spoken in isolation. There were a total of 54 stimuli whose durations ranged between 98 and 271 ms. These stimuli were randomized in the listening test.

None of the Swedish listeners used [ɨ] in their own speech. They were first asked if they recognized the sound as 'Lidingö i' (which, as noted, is the usual term in the Stockholm area) and were asked to imitate it. If they were reasonably successful in recognizing and imitating the sound, they were accepted as participants in the test. In the test, Swedish listeners were asked to judge each stimulus as either 'an acceptable instance of Lidingö i' or 'not an acceptable instance of Lidingö i'. The Turkish listeners were asked to judge each stimulus as either 'an acceptable instance of ı' or 'not an acceptable instance of ı'.

5.3. Results and discussion

This experiment was designed to test the hypotheses whether a) Swedish listeners would accept Turkish [ɨ] as a member of the category 'Lidingö i', i.e., one of the Swedish dialectal variants of [ɨ] and, conversely, b) whether Turkish listeners would accept the [ɨ] variants of some Swedish dialects as members of the Turkish [ɨ] category. Figure 1 shows that both hypotheses were largely borne out. For the Swedish speakers, the Orust [ɨ] variant gave the highest number of positive responses (96 %), followed by Turkish [ɨ] (78 %). Kräklinge and Göteborg [ɨ] gave lower figures (69 % and 40 % respectively). For the Turkish listeners, Turkish [ɨ] gave the highest number of positive responses (96 %), followed by Orust [ɨ] (68 %). Kräklinge and Göteborg gave lower figures. Practically no high front unrounded [i]'s were identified as [ɨ]. This suggests that both Swedish and Turkish listeners tend to accept Turkish and Orust [ɨ] as 'the same sound'. Also, listener responses to Göteborg and Kräklinge [ɨ] support to some extent the above suggestion that the damped [ɨ] sounds of the Swedish dialects are not typologically unusual, but can be grouped together with high central unrounded [ɨ] of, at least, Turkish.

What is the main acoustic correlate of this 'damped' vowel quality? Figure 2 illustrates, for the Swedish listeners, that the number of positive responses increases when F_2 decreases. A two-tailed Spearman's rank correlation test reveals a significant negative correlation between F_2 and number of positive responses for both Swedish and Turkish listeners ($p<0.01$), whereas there is no significant correlation either with F_1 or stimulus duration. Furthermore, the correlation between the responses of the Swedish and Turkish listeners is significant. It can thus be concluded that a low F_2 is a primary acoustical determinant of the perceptual character of these vowels.

6. CONCLUSION

An acoustic analysis, an articulatory simulation experiment and a perception test have been carried out to clarify the phonetic-typological position of the damped vowel sounds of some Swedish dialects. The results suggest that these vowels are members of the category of high central unrounded vowels, and that this vowel category is a fairly wide-spread one among the world's languages. It can be assumed that this vowel type is produced with apicalization in some languages since, according to the above simulation experiment, this would further enhance its damped quality. However, these conclusions remain tentative in view of the limited empirical evidence available so far.

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