

# THE ACQUISITION OF HUNGARIAN HIGH FRONT UNROUNDED SHORT VS. LONG VOWELS

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## ABSTRACT

This study examined spectral properties of the Hungarian vowel pair /i/ vs. /i:/ with contrasting phonemic vowel lengths in 2;0 and 4;0 years old boys acquiring Hungarian as their native language. Results were obtained by an automated pitch-synchronous bandfilter analysis method that estimates the spectral envelope representation of vowels. Subsequent data reduction was achieved via principal component analysis.

Findings show that 4;0 years old boys produce more peripheral vowels, due partly to an increased lip-jaw coordination ability. Additionally, the vowel space of older children contains more compact vowel spaces corresponding to each vowel. Spectral features of /i/ vs. /i:/ differ in 4;0 years old as opposed to 2;0 years old boys.

**Keywords:** vowels, children, Hungarian, phonemic vowel length, spectrotemporal analysis

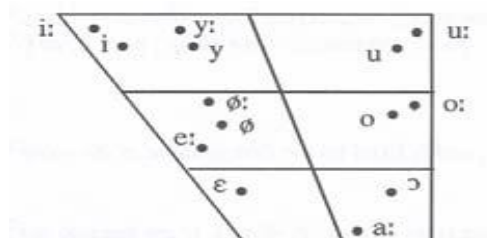
## 1. INTRODUCTION

Many languages code differences in meaning by using contrasting phonemic vowel length. In the UPSID317 database, 19.6% of the languages examined apply this differentiation to allow for semantic identification [3]. The standard dialect of Hungarian, a Finno-Ugrian language uses a two-way phonemic vowel length contrast that is characterized by an average duration ratio of 1:2 [2, 8].

Standard Hungarian uses phonemic vowel length as a primary feature to differentiate five of its seven vowel pairs: /i/ vs. /i:/, /o/ vs. /o:/, /ø/ vs. /ø:/, /u/ vs. /u:/ and /y/ vs. /y:/. Additionally, the members of these vowel pairs are also differentiated by a secondary distinguishing feature of spectral contrast. (Members of the remaining two vowel pairs, /ɔ/ vs. /a:/ and /ɛ/ vs. /e:/, are contrasted by both durational and substantial spectral differences; for the acoustic representation

of the adult Standard Hungarian vowel space, see Figure 1).

**Figure 1:** The vowel space of Standard Hungarian (modified from Szende [7]).



This study examined the acquisition of the vowel pair /i/ vs. /i:/. In adult Hungarian, members of this vowel pair are primarily differentiated by durational cues. The secondary differentiating feature is a relatively subtle spectral difference.

Previous results [10] indicate that children between 2;0 and 4;0 years differentiate the durational cues of short vs. long vowels reliably. At the age of 2;0 years, children's /i/ vs. /i:/ vowel pairs (the stressed first vowels in /pipi/ 'small chicken' vs. /pi:pi:/ 'animal calling word for chicken') are produced with a duration ratio of 1.48 (means are 112.97 vs. 167.50 ms, respectively), while at the age of 4;0 the ratio is 2.43 (means are 84.07 vs. 204.63 ms, respectively). The objective of the study was to map out developmental trends in the production of phonemically short vs. long vowels /i/ vs. /i:/ via taking spectrotemporal measures.

## 2. METHODOLOGY

This study utilized a cross-sectional study design to explore developmental tendencies in the spectral properties of the vowels /i/ vs. /i:/ with contrasting phonemic vowel lengths. The study is part of a larger research project that explores vowel acquisition processes in children cross-linguistically; for specific details of setup and procedures, see [5, 6, 9, 11, 12].

## 2.1. Participants

Participants included 5 boys at the age of 2;0 years ( $\pm 2$  weeks) and 5 boys at the age of 4;0 years ( $\pm 2$  weeks). The children were monolingual native speakers of the standard dialect of Hungarian, who did not have substantial exposure to other dialects or languages. Family members also spoke standard Hungarian. Families lived in the greater Budapest area. All children had an uneventful health history.

## 2.2. Experimental setup and procedures

Participants and their caregivers were instructed to play with stuffed animals in a sound attenuated room ( $\sim 6 \text{ m}^3$ ). The stuffed toys had pre-assigned CV(:)1CV(:)1 structured names (e.g., /pipi/ vs. /pi:pi:/) sewn on their back to help the caregiver recall the toy names. Caregivers were asked to attempt to elicit the production of tokens from each child at least five times during a naturalistic interaction. Tokens with short vs. long target vowels were recorded during two separate sessions that were scheduled for less than two weeks apart.

## 2.3. Recording procedure

The Sound Forge acoustic recording software (Version 5.0, Built 117) was utilized for the recording of speech samples with recording attributes set to 32 kHz, 16 bit, mono.

## 2.4. Data selection

Data selection was carried out by a monolingual Hungarian speaker. Tokens with two correctly produced vowels were selected perceptually. A second judge rated 10% of the dataset for reliability. Inter-rater agreement for each vowel category exceeded 90%.

## 2.5. Data analysis

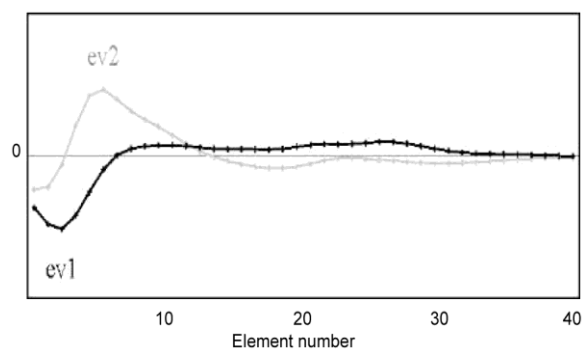
Data analysis was carried out by using an automated pitch-related bandfilter analysis method that allows for an acoustically unbiased measurement of formant measures. The method estimates the spectral envelope representations of vowels. All selection and analysis procedures were carried out by scripts in Praat [1].

Individual CV(:)1CV(:)1 productions were subjected to analysis as unlabeled tokens. Specified intensity criteria were used to avoid clipped segments and low intensity fragments. To bandfilter the selected part, the F0 period nearest to the selection was recirculated to generate a

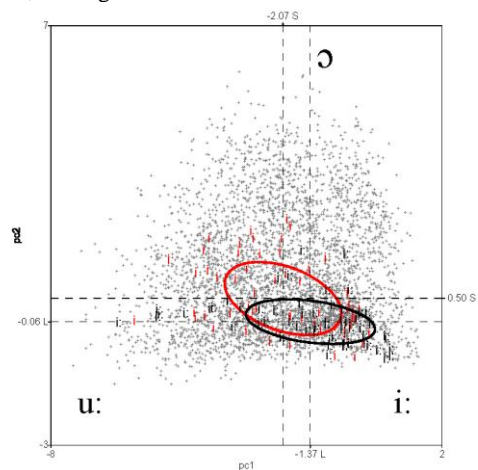
sufficiently long signal. Signal filtering was carried out by the application of a Gauss bandfilter, tuned to 0-7 kHz in 40 steps of 175 Hz. Bandwidth was set to  $1.1 \times 425 \text{ Hz}$ . The resulting spectral envelope contains spectral intensities of 40 adjacent frequency bins of 175 Hz width. Each measurement represents a point in a 40 dimensional space.

Principal component analysis was used to reduce the data set. This approach has been used successfully to generate vowel production charts in both adults [4] and children [5, 6, 11]. A new space was then generated, with pc1 representing the component with the largest variance and pc2 representing the component with the second largest variance, etc. The first two principal components created a vowel space (defined by its first two eigenvectors; see Figure 2), with pc1 showing resemblance to F2 and pc2 showing resemblance to F1 (see Figures 3A-B).

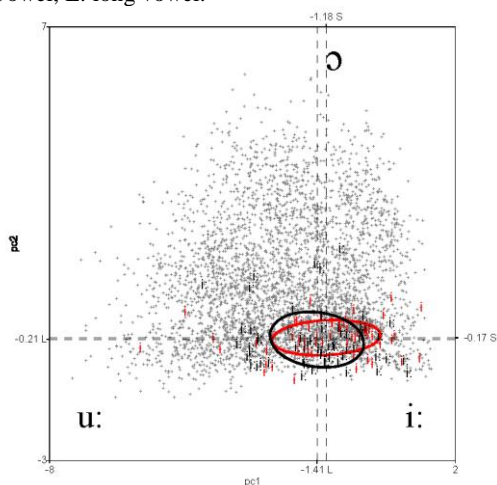
**Figure 2:** Graphs of the first two eigenvectors of a PCA of the measurement points for the reference plane, explaining  $26.2 + 18.9 = 45.1\%$  of the total variance.



**Figure 3A:** Vowel categories of 2;0 years olds (/i/ vs. /i:/) projected onto the reference plane. Each ellipse represents 1 SD from the mean of measured variance. Red/grey: short vowels; Black: long vowels. S: short vowel, L: long vowel.



**Figure 3B:** Vowel categories of 4;0 years olds (/i/ vs. /i:/) projected onto the reference plane. Each ellipse represents 1 SD from the mean of measured variance. Red/grey: short vowels; Black: long vowels. S: short vowel, L: long vowel.



To allow for a developmental comparison of vowel categories in 2;0 and 4;0 years old boys, a pc1-pc2 reference plane was created by using data from all 4;0 years old boys. Vowel spectra measures from 687 CV(:)1CV(:)1 tokens containing 1374 vowels that included all Hungarian monophthongs from all 5 boys in the tokens /baba/ (n=49); /bubu/ (n=41); /gøgø/ (n=49); /køkø/ (n=46); /le:le:/ (n=45); /lolo/ (n=52); /lo:lo:/ (n=43); /mymy/ (n=30); /my:my:/ (n=44); /nyny/ (n=48); /pa:pa:/ (n=54); /pepe/ (n=49); /pipi/ (n=47); /pi:pi:/ (n=42); /pu:pu:/ (n=48) were analyzed to create a pc1-pc2 plane. The plane, which is defined by a set of eigenvectors, includes 4372 measurement points indicated by grey plus signs in the figures. To determine the location of the corner vowels within the vowel space, tokens containing the vowels /i:/, /u:/ and /ɔ:/ were analyzed and projected onto the reference plane. To indicate the vowel qualities produced in each corner vowel region, corner vowel qualities marked with the signs ‘ɔ’, ‘u’ and ‘i:’ are placed in the vicinity of each corner.

Children’s labeled tokens elicited by the caregivers were analyzed according to the target token. All 2;0 old boys produced 16 tokens for each category of /pipi/ (yielding 66 measurement points) and /pi:pi:/ (yielding 70 measurement points). 4;0 year-olds produced 21 tokens for each category of /pipi/ (yielding 114 measurement points) and /pi:pi:/ (yielding 143 measurement points). Thus, overall 74 tokens were analyzed containing 148 vowels (yielding 393 measurement points). To determine the location and dispersion

of the vowel categories /i/ vs. /i:/ within the reference plane, a randomly selected 60 measurement points from each of the four vowel categories (/i/ and /i:/ at 2;0 and 4;0 years) were projected onto the pc1-pc2 reference plane. An ellipse was created for each category that represents 1 SD from the mean of the measured variance. Results are shown in Figures 3A for 2;0 years old boys and 3B for 4;0 year-olds.

### 3. DISCUSSION

Mapping out the results in Figures 3A and 3B helped to identify a number of production characteristics and developmental tendencies that are reflected by the children’s data. Results are reviewed by comparing the acoustic properties of individual vowel categories both within and between age groups. Then, a short summary is provided for reviewing general acquisition trends.

#### 3.1. Vowel category comparison within age groups

At 2;0 years, boys produce vowels that are relatively centralized. However, phonemically short /i/ vowels are more centralized than their long /i:/ pairs, indicating less stability of production patterns in short as opposed to long vowels. In contrast with the long vowels, the majority of short vowels are realized with lower jaw position. The area of the ellipses (3.95 vs. 2.59, respectively) indicate that, during the production of the long vowels children hit a more concentrated target area of the vowel space more consistently. That is, during the production of longer vowels, children have longer time to position their articulators to the required position. (See Figure 3A.)

At 4;0 years, both vowels are realized with a higher jaw position. Centralization tendencies are diminished. The areas of the ellipses (1.69 vs. 2.31) indicate more consistency in the production of the short vowel. That is, long vowel duration results in changing vowel characteristics. (See Figure 3B.)

#### 3.2. Vowel category comparison between age groups

Developmentally, vowels produced by older children are more fronted, even though producing the vowels in a front position is still a challenge at 4;0 years. The corner vowel position is being hit less frequently, showing limitations in fronting.

The vowel categories are produced in more compact regions of the vowel plane. The area occupied by /i/ decreased by 57.22% from 2;0 to 4;0 years. The area of the /i:/ vowel category decreased by 10.81% during the same period. Thus, a tendency to produce individual vowel categories with more consistency was documented.

#### 4. SHORT SUMMARY

Examining the spectral differentiation of vowels with contrasting phonemic vowel lengths is an important step towards formulating a theory of vowel acquisition. Previous results of perceptual studies [9, 12] show that the vowel acquisition process is clearly not completed in 4;0 year old boys acquiring the standard dialect of Hungarian, as reflected perceptually.

Overall, results of the current study show that vowels produced by 4;0 years old as opposed to 2;0 years old boys are more peripheral and produced with more consistency, due partly to 1) an increased ability to produce vowels with higher (more closed) jaw position, 2) increased skills for formulating appropriate lip positioning, 3) a heightened ability to more precisely coordinate lip positioning with higher and more frontal tongue positions, and 4) an increased ability to maintain lip/jaw positions for longer duration, along with less variability in articulatory movements during the production of a vowel. In general, the more compact ellipse areas of individual vowel categories in older children indicate higher level speech production skills used during vowel production in tokens.

However, previous results of perceptual studies [9, 12] clearly underline the unfinished nature of the vowel acquisition process in children at 4;0 years of age; vowels produced by 4;0 year-old children are not yet adult-like perceptually. In addition, many of the perceptually identified vowel error patterns clearly support limitations in vowel production abilities in older 4;0 years old children. These findings may be due to different patterning in spectral features.

Clearly, more detailed studies applying acoustic analysis are required to uncover major tendencies in children's vowel production. Further studies controlling for a wide range of factors are needed before conclusions can be drawn about trends in vowel acquisition in monolingual children.

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