Vowel duration contrast in three long-short pairs by Hungarian 5-, 6-, and 7-year-olds

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Abstract. *Purpose*. This study focuses on phonemic vowel quantity differentiation in 3 pairs of short versus long vowels (/i, iː, o, oː, u, uː/) by 5-, 6-, and 7-year-old monolingual Hungarian-speaking children. We hypothesized that there would be vowel quantity and vowel quality differences and also a trend toward greater vowel differentiation as children aged. *Method.* Participants included 3 groups of monolingual Hungarian-speaking children: 5-year-olds (n=6), 6-year-olds (n=7), and 7-year-olds (n=14) recruited from Hungarian public schools. The participants had typical cognitive skills, speech, language, and hearing within normal limits per parent and teacher report. Audio recordings were collected via conversational samples as the children interacted with an experimenter, discussing favorite pastimes, everyday lives, or favorite stories. Vowels were analyzed using PRAAT 5.0 (Boersma & Weenink, 2015) except final vowels and distorted productions or substitutions. *Results*. There were statistically significant effects for vowel quality (F (2, 42) = 10.12 at p = 0.000, partial η^2 = 0.33) and vowel quantity (F (1, 21) = 67.49 at p = 0.000, partial η^2 = 0.76), but no age effect or age by quantity interaction were found. Our results provided support for our predictions regarding differences based on vowel quantity and quality; however, age and age by quantity interaction effects were not found. *Conclusions.* Overall, our participants did distinguish vowels based on duration and vowel quality, but those distinctions did not depend on age, possibly indicating that differentiation may occur as early as 5 years of age. Further research is needed to verify our findings using more participants and longitudinal data to track the development of the phonemic contrast between short and long vowels in Hungarian.

Keywords: Hungarian, child phonology, vowel quantity and duration, vowel quality, short/long vowels, conversational speech

Introduction

Phonemic use of vowel duration differs across languages, ranging from no functional vowel quantity discrimination (as in Spanish, cf. Malmberg, 1971), to duration used only as an acoustic cue but not a phonological feature (as in English, cf. Kassai, 1979), to vowel duration used as both an acoustic cue and a phonological feature (such as Hungarian or Estonian, cf. Lehiste, 1965). Languages that do use vowel quantity as a phonological feature (i.e. distinguish vowel duration on a phonemic level) have two distinct vowel duration categories, such as long versus short vowels as in Hungarian or even three phonemic levels based on vowel duration. as does Estonian (Lehiste, 1965). Note that in the relevant literature, both vowel quantity and vowel length are used to refer to phonemic differentiation of vowels based on duration. We opt for the former, because length can also imply measurement of distance, so we chose our course of action in the interest of precision.

Vowel quantity is a distinctive phonological feature in Hungarian, having 7 pairs of short versus long vowel phonemes in the language: /i – iː, y – yː, ø – øː, ɛ – eː, u – uː, o – oː, ɒ – aː/ (Nádasdy & Siptár, 2001). Nonetheless, from a purely phonetic point of view, only 5 of the phonemically short versus long pairs differ primarily on duration: /i – iː, y – yː, ø – øː, u – uː, o – oː/ (Gósy, 2004), the other two pairs (/ɛ – eː, ɒ – aː/) display qualitative as well as durational differences (see Figure 1 below based on Szende, 1994).

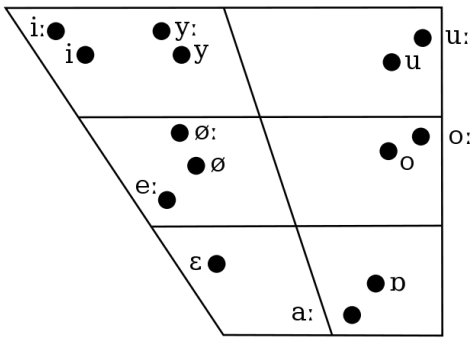

Figure 1. The Hungarian vowel system (Szende, 1994)

It must be noted that the phonemic feature of vowel quantity does not always manifest itself consistently in a physically measurable fashion; for example, the duration of phonemically short versus phonemically long vowels can have an overlap ranging from 28% (Thai) to as high as 90% (German), depending on the language (Lehiste, 1970). Factors such as vowel quality, tempo, position of the vowel, word length, and others affect vowel duration in Hungarian (Gósy & Beke, 2010). However, in Hungarian, despite variations in duration due to factors noted above, the durational differences distinguishing short from long vowels are maintained to the degree that the categorical distinctions persist. For example, irrespective of stress patterns, Hungarian vowels maintain the short versus long contrast in a measurable fashion pertaining to their duration (Gósy & Beke, 2010). Moreover, short and long vowels maintain their durational differences in isolated words read out loud as well as in spontaneous, conversational speech even though some overlap does exist between the vowel quantity categories (Bóna, 2012; Gósy & Beke, 2010). The drive to maintain the durational differences between short and long vowels in Hungarian is so strong that evidence can be found even in the speech patterns of elderly adults (over 70 years of age) where vowel quality differences become reduced, yet durational differences are maintained, albeit not as notably as in the case of younger adults (Bóna, 2012).

In terms of phonological acquisition, vowel duration is one of the last contrastive vowel features acquired by monolingual Hungarian-speaking children, and one to undergo gradual development starting with certain pairs (e.g., /i/ - /i:/) around 4 years of age and in limited contexts (Zajdó & Powell, 2008). However, differences in vowel duration are still not completely mastered in an adult-like fashion in all 7 short-long vowel pairs by 6 years of age (Bóna & Imre, 2010; Deme, 2012). Consequently, our study investigates vowel quantity differentiation in 3 pairs of vowels that only differ in duration (/i, i:, o, o:, u, u:/) between the ages of 5;0 and 7;11 to investigate the changes, if any, occurring in this age range. We focus on the vowel pairs noted above, because these contrasts differ primarily on duration and the pairs are qualitatively very similar, so this allows for investigating the discrimination of the durational contrast avoiding the confounding factor of possible qualitative differences.

Zajdó (2002) found that children at age 3 were able to produce adult-like short and long vowels with 90% mastery level while imitating their caregivers' productions of two-syllable items, such as *pipi* /*pipi*/ (= small chicken) and /*pi:pi:/* (non-word), using puppets that bore the target names. Children displayed more accurate and earlier pronunciations of unrounded vowels relative to rounded ones. The measurement involved perceptual judgements by an adult native Hungarian speaker. In a follow-up study, Zajdó (2015) found that Hungarian-speaking children between 2 and 4 years of age were able to modify vowel duration based on the caregiver's model. As in the previous study, the tokens were CV(:)CV(:) labels, such as /pipi/ versus /pi:pi:/, given to puppets, and the participants' caregivers provided the model in continuous speech. The caregivers were asked to elicit the names of the puppets during their interactions with the children.

In the absence of an adult model that young children could imitate, the separation of short versus long vowels based on duration appears to be less certain. Bóna and Imre (2010) found that in

conversational speech samples, only children between 5 and 6 years of age began to separate short and long vowels in a systematic fashion in their productions. Furthermore, even by 6 years of age, not all vowel pairs displayed clear differentiation based on duration in the samples of Hungarian-speaking children. Specifically, only /o/ versus /o:/ and /u/ versus /u:/ showed statistically significant differences based on vowel duration. These results were later replicated by Deme (2012) who investigated the short and long vowels of 6- to 7-year-olds, demonstrating statistically significant vowel duration differences in the same pairs only (/o/ - /o:/ and /u/ - /u:/).

The lack of unequivocal differentiation between short and long vowels may also have perceptual underpinnings. Gósy (2006) found that Hungarian-speaking children could only differentiate vowel duration accurately in perception 28% of the time at 5 years of age, 65-70% at 7 years of age, and 75-80% of the time between the ages of 8 and 9 years. Based on these results, there appears to be a considerable increase in accuracy to perceive short versus long vowels between the ages of 5 and 7 years. Consequently, studying the duration of vowels produced by Hungarian-speaking children in this age range may reveal important insights into the development of vowel duration differentiation, specifically, and speech development, more generally. The main research question is how phonemic vowel quantity discrimination manifests itself in the conversational speech samples of 5- to 7-year-old monolingual Hungarian-speaking children. A related question is how and if vowel quality affects vowel durations and their differentiation. Finally, would there be an interaction between the different age groups and durational differences? In other words, does the differentiation of vowels based on duration depend on age? Based on existing research on and the research questions above, we posit the following hypotheses:

1) We expect to find differences in vowel duration both at ages 5 and 7.
2) As vowel quantity contrasts develop, we predict an age effect in that durational differences will be better expressed at age 7 than at age 5.
3) We expect there to be an effect of vowel quality on the duration of the vowels and also predict differential quality effects on the different short and long vowel pairs.

Method

Participants

The present study adheres to the ethical guidelines provided by the Hungarian review board that oversees the ethical treatment of human subjects in research. Written parental consent and child assent were obtained prior to the execution of the study from each of the children and their parents or legal guardians. There were 3 groups of monolingual Hungarian-speaking children: 5-year-olds (n=6), 6-year-olds (n=7), and 7-year-olds (n=14) recruited from Hungarian public schools in the Budapest metropolitan area. The participants had typical cognitive skills, speech, language, and hearing within normal limits per parent and teacher report. The socio-economic status of the participants was not controlled; however, all of the children were recruited from public schools from the same area and were typically from Hungarian middle-class families.

Materials and Procedure

Audio recordings were collected via conversational speech samples as the children interacted with an experimenter, discussing their favorite pastimes, everyday lives, or favorite stories. These interactions were quasi-naturalistic to prompt conversational samples from the participants and, at the same time, provide a somewhat controlled context so that the samples would be comparable. Recordings were conducted at school (kindergarten or elementary) in a quiet room to provide familiar environment for the children using a Zoom H4n portable recorder. Each recording session included a minimum of 5 minutes of conversation between the participant and the experimenter.

In order to control for factors affecting vowel duration, the following criteria were used for selecting vowels for analysis:

a.) Only allophones of /i/, /i:/, /o/, /o:/, /u/, and /u:/ were analyzed to control for vowel quality and to ensure that the pairs would only differ in duration. In addition, as vowel pairs, these are among the most frequently occurring ones in Hungarian (Gósy, 2004).
b.) Distorted productions of vowels (such as substitutions or hesitations) were excluded from the analyses.
c.) Terminal vowels (i.e. vowels in absolute final position) were not included in the analyses.

The final data set included a total of 2413 vowels whose durations were analyzed using PRAAT (Boersma & Weenink, 2015). Table 1 displays the number of vowels analyzed per each phonemic category. The segmentation of the vowels was based on their second formants supported by visual analysis of their respective wide-band spectrograms and waveforms. All of the vowel measurements were verified via interrater reliability by two of the authors of this paper. Items that were in disagreement were discarded from the analyses.

Table 1. Number of the analyzed vowels

Vowel	Short	Long
[i]	754	169
[o]	866	269
[u]	262	93
Total	1882	531

After obtaining and verifying the measurements, the durations of the vowels were analyzed using a repeated measures ANOVA. The independent variables were age with three levels (5-, 6-, and 7-year-olds; between-subjects variable), vowel quantity with two levels (short versus long; within-subjects factor), and vowel quality with three levels (/i, i:/, /o, o:/, and /u, u:/; within-subjects factor). The dependent variable was the duration of the vowel measured in milliseconds.

Results

Before conducting the analyses for testing our hypotheses, we verified that our data adhered to the assumption of sphericity. In order to test this assumption, we conducted Mauchly's tests of sphericity and found no statistically significant ones for the within-subjects effects and their interactions, suggesting that the variances of the differences between all pairs of related groups were equal. Consequently, the F ratios for our ANOVA were interpretable and valid.

Our first hypothesis predicted that we would find differences in vowel duration between phonemically short versus long pairs for all the participants. This hypothesis was supported by a main effect for vowel quantity [F (1, 21) = 67.49 at p = 0.000, partial η^2 = 0.76]. Figure 2 below displays the means for vowel duration in milliseconds and their respective standard deviations per vowel for each age group.

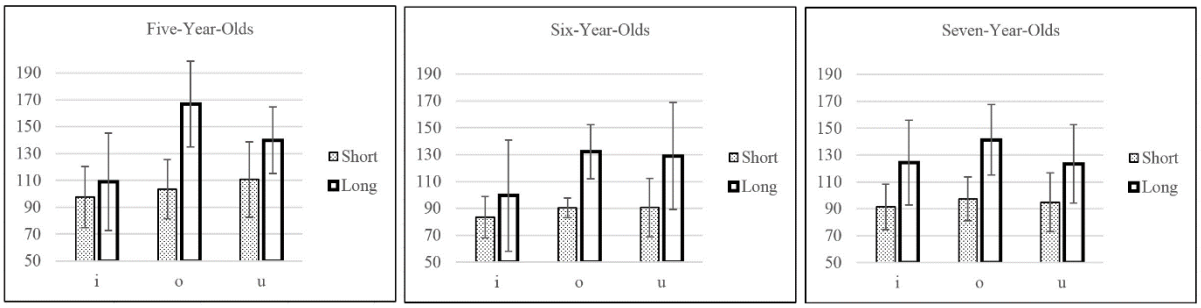

Figure 2. Mean vowel durations in milliseconds and their standard deviations

The second prediction was that as vowel quantity contrasts developed, age effects would be better expressed at age 7 than at age 5. In order to test this hypothesis, we investigated the main effect of age as well as the interaction effect of age by vowel quantity. Neither the main effect for age [F (2, 21) = 3.03 at p = 0.070, partial η^2 = 0.224], nor the interaction between age and vowel quantity were statistically significant [F (2, 21) = 0.18 at p = 0.838, partial η^2 = 0.017]. These findings suggest that age did not have an effect on vowel duration, and vowel quantity differentiation also did not depend on the age of the participants.

According to our third hypothesis, we expected to find an overall vowel quality effect as well as a dependence of that effect on the quantity of the vowel. This hypothesis was supported by our data in that there was both a main effect of vowel quality [F (2, 42) = 10.12 at p = 0.000, partial η^2 = 0.33] as well as an interaction effect for vowel quality by vowel quantity [F (2, 42) = 5.69 at p = 0.007, partial η^2 = 0.213]. These results indicate that vowel quality affects vowel duration in general and the effect of vowel quality depends on the quantity of the vowel (short versus long). Figure 2 above illustrates the differences between the vowels depending on their quality and quantity, separated by age.

Discussion

Overall, our findings suggest that Hungarian-speaking children do differentiate short and long vowels based on segmental duration in their conversational speech production, and vowel quantity is produced in a distinct fashion even at 5 years of age. Furthermore, contrary to our prediction that vowel quantity discrimination would depend on age, we did not find an age by vowel quantity interaction, suggesting that 5-year-olds, 6-year-olds, and 7-year-olds may not produce short versus long vowels in a unique fashion. It is also possible that such an interaction exists but the limitations of our data (discussed further below) did not allow us to find the effect, so further research is needed in this area.

Regarding the effects of vowel quality on vowel duration, we found support for both the idea that there is an overall quality effect, but perhaps more importantly, we also found evidence that vowel quality has a differential effect on vowel quantity. That is to say, the quality of the vowel interacts with vowel quantity, so short versus long vowels may be affected differently based on the quality of the vowel.

Our study contributes novel information to the literature, but it is not without its limitations. Future studies should employ a longitudinal design as well as a larger number of participants. Another limitation is that our data are based on conversational speech samples, so the linguistic environment could not be completely controlled. However, having conversational speech recordings does reflect naturalistic spontaneous speech, so in that respect our data are more representative of real speech than more controlled samples (such as single-word elicitation tasks). In the future, it would be desirable to include both conversational and controlled speech samples and compare the two to investigate the effects of the linguistic environment on vowel quantity and quality. In addition, our study did not compare the productions of children to the adult target, so studies should also incorporate comparisons of children's productions to the adult target to investigate the age at which vowel durations become adult-like.

The present study represents pilot work that added information to our knowledge base regarding the acquisition of phonemic vowel quantity contrasts in monolingual Hungarian-speaking children. Our data also generated new questions regarding how vowel quantity contrasts develop and at what age they become adult-like, prompting a need for further research in the area as well as providing specific direction for subsequent studies.

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