THESE OF DOCTORAL DISSERTATION

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THE ACOUSTIC-PHONETIC CHARACTERISTICS OF VOWELS IN HUNGARIAN CHILDREN

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1. **INTRODUCTION**

The children gradually acquire their mother tongue during the first few years. In their speech at first quantitative development (the development of speech is very impressive and fast in the first three years) then after six years mainly qualitative changes can be observed (Gósy 2005).

The first sound of the infant is similar to the later ö, á vowels. Later they are mainly articulate sound sequences which contain vowels e, o, u. At the age of 6 months they articulate vowel a more frequently. The vowels i and e appear clearly in the last quarter of the first year. Between the age of 12 and 24 months the collection of sounds is quite rich, the number of missing vowels and the improperly articulated speech sounds is reduced, and almost every vowel can be found in the speech (expect ö, ŏ, ü, ű) (Gósy 2005).

The investigation of vowels during childhood is especially important, because it provides useful information about the process of language acquisition, the acoustic and phonological changes of speech production. In childhood the physical structure of the body is continuously changing, thereby the length, shape and volume of the vocal tract are also changing which affects the acoustic structure of the vowels (Gósy 2004). It was proved by several analyses that by the increase of body size, the formant values of vowels are linearly decreasing (Peterson–Barney 1952; Fant 1966; Nordström 1975; Hillenbrand et al. 1995; Huber et al. 1999; Lee et al. 1999; Fitch–Giedd 1999; Vorperian et al. 2005; Ishizuka et al. 2007; Vorperian–Kent 2007; Watson–Munson 2007).

Children have relatively few speech and communicational experience, therefore their articulation is untrained yet. Their articulation is less automatized. It is frequent that their articulation does not reach the right configuration, which shows the inexperience of motoral (see Goldfield–Kay–Warren 1993; Jeannerod 1988). Later, by the increase of ages there is progress in this aspect (Temple et al. 2002).

The duration of the vowels is effected by the age of the speaker, the speech production of the children is significantly different from the adults’. Several research proved that the articulation and speech rate of the children is slower than the adults’ (in the first 10 years), but by the increase of ages gradual acceleration can be observed (Lee et al. 1999; Logan et al. 2011; Laczkó 2009; Deme 2012b). The variety of the duration of the speech sounds is decreasing according to a research was made by English children between the age of 9 and 12 and the duration values of 12-year-olds are getting similar to adults’ (Lee et al. 1999). In the speech of children there were greater acoustic variability than in adults. Therefore the vowel space area in children is significantly greater than in adults (Pettinato et al. 2016).
It is well researched that in which age there will be significant difference in the formant structure of vowels between boys and girls. We find different result in literature. It was found that there is difference between boys and girls at the age of 4, but it becomes significant around 7–8 years (Vorperian–Kent 2007). Because of the size of the vocal tract the formant values are lower in boys than in girls (Bennett 1981; Busby–Plant 1995; Perry–Ohde–Ashmead 2001; Whiteside–Hodgson 2000). Lee et al. (1999) found difference between boys and girls from the age of 11 which became significant at the age of 15 in the cases of the second and the third formant. There is no consensus that this is linear by the increase of the age (Whiteside 2001). Flipsen and Lee (2012) confirmed that the vowel space area of girls is bigger than boys from the age of 16. The reason of this findings is partly the physiological difference between boys and girls and also the hyperarticulation which is typical in girls (Simpson 2009).

2. THE STRUCTURE OF THE DISSERTATION

The dissertation consists of five chapters. We investigated the vowel formant structure and duration of children between the age of 7 to 13 years in spontaneous speech.

Chapter 1 is the Introduction. It describes the language acquisition and the stages of the language development: the physiological background the articulation of vowels. We summarize the literature (mainly the Hungarian) about the formant structure and duration of vowels in children and adults. This chapter is including specification of the topic of dissertation, setting the general aims of the research and its main hypotheses.

Chapter 2 introduces the subjects involved, the corpora used for the research, and the general methodology of the experiments.

The experimental results are discussed in Chapter 3 in 6 subchapters. Within the subchapters the detailed description of the results for each age is done by using the following structure: the formant structure of vowels [within that (i) short-long phonological vowel pair, (ii) first syllable position / not first syllable position, (iii) gender related differences, (iv) short-long phonological vowel pairs according to the speaker's gender], the duration of the vowels [within that (i) short-long phonological vowel pair, (ii) first syllable position / not first syllable position, (iii) gender related differences, (iv) short-long phonological vowel pairs according to the speaker's gender]. A separate subchapter discusses the data of adults. The last subchapter gives a brief summary of the differences between the vowels of children and adults.

Chapter 4 discusses the conclusions in general as well as in relation to the specific areas mentioned above.

Chapter 5 demonstrates the theses of the dissertation.
Finally, the references are listed at the end of the dissertation.

3. SUBJECTS, MATERIAL AND METHODS

In this research 80 children participated from four age groups: 7-, 9-, 11- and 13-year-old. In every age groups there were 10 girls and 10 boys. None of them had any hearing disorder. Their intelligence fell within the normal range. The control group consisted of 20 adult speakers (10 males and 10 females). They were chosen from BEA (Gósy et al. 2012) Hungarian spontaneous speech database.

The main material of the PhD-dissertation builds up from spontaneous speech recordings. We analysed 1-1 minutes from every recording. In our study we investigated 10 vowels: a, á, e, é, i, í, o, ó, u, ú. The aspects of the study: short-long phonological vowel pair, (ii) first syllable position / not first syllable position. We investigated the following parameters: the first and second formant, duration.

The labelling was carried out using Praat 5.2 (Boersma–Weenink 2011). We created a reference database (the dataset was measured manually) to find the proper formant tracker. We measured the data formant tracker made by Geoffrey Morrison. We deleted the outliers (which were at least 2 standard deviations away from the mean. We normalized the data with the method made by Lobanov. The statistical analysis (Generalized linear mixed model = GLMM) was conducted by the means of SPSS 13.0. Furthermore, we calculated the overlap ratio of the formants and the size of the vowel space area.

4. RESULTS

4.1. The vowel of 7-year-old children

In this age the vowels are well separated from each other based on both the horizontal and the vertical position of the tongue. We did not found significant difference in formant structure between the phonological vowel pairs a–á, e–é and o–ó. We only found marginal difference according to the first syllable/not first syllable position. We can conclude that position of the vowel within the word not affected the formant structure.

The gender related investigation brought the following results: the interaction of gender and vowel quality have a main significant effect on first and second formant. Both in girls and boys the formant structure of the vowels is well separated based on the articulation configuration.

The duration of phonologically short and long pairs is significantly difference (except: u–ú) in 7 years old children. Within both gender there is
durational opposition between the phonologically short and long vowels, but this difference is greater in boys than in girls.

We did not find any significant differences in case of first syllable and not first syllable position.

### 4.2. The vowel of 9-year-old children

In the cases of first and second formant we found that there are significant differences between the front and back vowels, and the vowels are also different depending on the vertical position of the tongue. The statistical analysis proved significant differences between the phonologically short and long vowels in the cases of $a$–$á$, $e$–$é$ and $o$–$ó$. We did not find mathematical differences between the vowels depending on whether it was in first syllable position or not first syllable position. The high and mid vowels did not clearly separated from each other either in boys or in girls. However, in the spontaneous speech of boys there were significant differences between the vowels depending on the vertical position of the tongue, but not in the girls.

The investigation of duration brought the following results: in the cases of the phonological pairs the short vowel statistically shorter that the long ones. It was proved both in boys and girls. The first syllable and not first syllable position had no effect on the duration.

### 4.3. The vowel of 11-year-old children

Depending on the vertical position of the tongue there were significant differences between the vowels (except between the high $i$ and the mid $ó$). The front and back vowels had been also clearly separated from each other in this age. In the cases of phonological pairs there were significant differences between the formant structure of vowels $a$–$á$, $e$–$é$ and $o$–$ó$.

The statistical analyses did not show significant differences between the formant structures of the vowels depending on whether it was in first syllable position or not first syllable position.

Both in boys and girls there were no significant differences between the high and mid vowels. In boys the vowels were clearly separated from each other based on the horizontal movement of the tongue (expect $e$–$ú$), but not in the girls.

In the spontaneous speech of 11-year-old children the phonologically short vowels are shorter than the long ones. We did not found mathematical differences between the duration of the vowels depending on whether it was in first syllable position or not first syllable position. There were not significant differences between boys and girls in the cases of the duration of the vowels.
Both in boys and girls there were significant differences in the cases of phonological vowel pairs between the short and long ones.

4.4. The vowel of 13-year-old children

In the spontaneous speech of 13-year-old children the front and back vowels are clearly separated from each other in the cases of formant structure. We found significant differences in the cases of phonological pairs between the short and long vowels (except i–í and u–ú). The difference was not proved mathematically whether the vowel was in first syllable position or not first syllable position. The gender related analyses showed the following results: in the spontaneous speech of boys the high u/ú and the mid ó did not separated from each other, but there were significant differences between the vowels depending on the horizontal movement of the tongue. In the spontaneous speech of girls based on both the horizontal and vertical movement of the tongue the vowels were clearly separated from each other.

In the cases of phonological pairs, the duration of the short vowels is significantly shorter than the long ones. Both in boys and girls this durational opposition is proved, but the difference is not significant between the short and long vowels in the cases of vowels i–í and u–ú either in boys or in girls. No significant difference was confirmed in the cases of first/not first syllable position.

4.6. The difference of vowels between children and adults

Based on the formant values we can say that the size of the vowel space area is gradually decreasing, but the vowels are getting more separated from each other. Both the value of the first and the second formant is decreasing by the age. This tendency is also proved in the cases of duration of the vowels.

5. Conclusions

The goal of the present research was to shed light the age-specific characteristics of 10 vowels’ formant structure and duration in the period of 7 and 13 years. The analysis had manifold aspects (phonological pairs, first/not first syllable position), and was carried out on 80 children’s and 20 adults’ spontaneous speech material. In this study, we aimed to answer several questions: (i) what kind of differences can be observed in formant structure and duration of the vowels between the different age groups, (ii) had gender significant main effect on the formant structure and duration of the vowels, (iii) is there any difference between the vowels acoustic-phonetic structure
depending on whether the vowel is in first syllable or not in first syllable position, (iv) is there any difference between the phonologically short and long vowels, finally (v) in which age can we find similar formant and duration values to adults.

Statistical analysis was carried out in order to confirm the statistical relevance of the data. The following conclusions can be drawn based on the results.

1. With the increase of the age the size of the vowel space area is decreasing (expect in the cases of 9-year-old children).
2. The overlap ratio between the formants of the vowels is decreasing with the increase of the age.
3. The duration of vowels shows shortening and in the cases of the formant structure tendentious changes can be also observed as the children are getting older.
4. In the age of 13 some differences could be found between boys and girls in the cases of vowels’ formant structure, but this process does not end at that time.
5. In spontaneous speech there is no significant difference either in formant structure or in duration depending on whether the vowel appears in first and not in first syllable position.
6. In every age groups there is significant difference in the cases of phonological pairs between the short and long vowels.
7. By the age of 13 the formant structure and the duration of the vowels are getting similar to adults’.

6. REFERENCES


7. PUBLICATIONS BY THE CANDIDATE ON THE TOPIC OF THE THESIS


8. TALKS GIVEN BY THE CANDIDATE ON THE TOPIC OF THE THESIS

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