

The production of Greek voiceless fricatives by young children

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<https://doi.org/10.36505/ExLing-2021/12/0042/000515>

Abstract

The present study aims to identify age-related developmental patterns for the Greek language, by analyzing children's and adult's fricative productions. Frication duration, as well as first and second spectral moments (mean, variance) were measured in the first stressed syllable of real disyllable words produced by young children and adult female speakers. A significant effect of age was revealed for fricative duration, with children presenting significantly higher values than adults for all fricatives. The effect of age was also significant for the first and second spectral moments, but not for all fricatives, while the effects of place of articulation and post-fricative vowel on the examined parameters suggest similar intra-category differences for the different age groups.

Keywords: children, Greek, voiceless fricatives, duration, spectral mean, variance

Introduction

Several studies that have employed acoustic analysis in order to investigate the acquisition and development of speech in children indicate age-related differences in the development of children's obstruent productions (e.g. Nittrouer 1995; Nissen & Fox 2005; Li 2012). Differences in the acoustic and spectral characteristics of speech sounds produced by children and adults may indicate that children's articulatory gestures are not as precisely specified as those of adult speakers (e.g., Nittrouer 1995; Nissen & Fox 2005; Li 2012). Of particular interest has been the development of the voiceless sibilant contrasts, which are also important since these sounds are often among the ones presenting articulatory disorders (Bernthal et al., 2018). Moreover, exposure to a specific language seems to play an important role on the way children develop speech, suggesting different developmental patterns even for speech sounds that are common across different languages (Li 2012).

With regards to the production of Greek fricatives, Nirgianaki (2014) has investigated fricatives produced by Greek speaking adults, finding significant differences among the different places of articulation, such as temporal, spectral and amplitudinal. However, the acoustic studies on the description of Greek sounds produced by children are rare and, focus on a limited subset of fricatives either singleton or in clusters (e.g., Syrika et al. 2011).

In this line of research, the present study aims to investigate temporal and spectral characteristics of Greek voiceless fricatives, and particularly, duration, first and second spectral moments (M1-mean, M2-variance), as produced by young children compared to those produced by adults.

Method

The Greek voiceless fricatives /f θ s ç x/ were recorded in real two-syllable words of the form 'CVCV within the carrier phrase /i i'kona 'ðixni 'ena/'mia ___ / ("The image shows a ___"). Each fricative was in initial position, followed by all five Greek vowels (/a e i o u/). Words beginning with /x/ were only followed by the vowels /a o u/, since the allophone /ç/ appears before the front vowels /e i/. Each participant was prompted an image of the target word and the written phrase "The image shows a ..." (next to the image), and then listened to the phrase. Nine female speakers, 3 in each of the age groups 3-6, 23-26 and 53-56 years old, produced the experiment's material three times at a normal tempo in a quiet room. A consent form was signed by the parents. Duration, as well as first and second spectral moments (M1-mean, M2-variance) -in the middle of each fricative- were measured in Praat software (Boersma & Weenink 2019). SPSS (v26) was used for data statistical analysis.

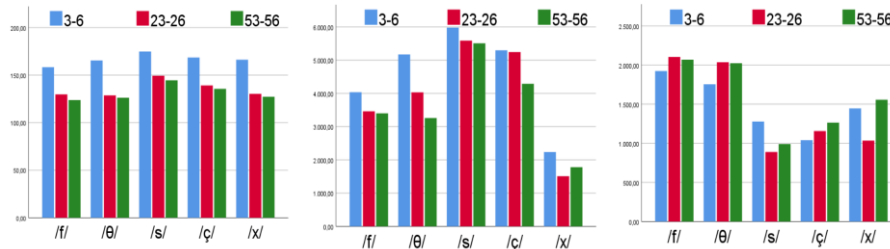
Results

A 3-way Anova (age group X place X vowel) with fricative duration as the dependent variable revealed a main effect of the age group ($F(2)=143.302$, $p<0.001$). Post hoc tests indicated significantly higher values for the children's group than both adult groups. Subsequent tests for each fricative separately, revealed significant differences between children and adults for all fricatives. A main effect was also revealed for place of articulation ($F(4)=14.460$, $p<0.001$), with the alveolar fricative /s/ being significantly the longest, followed by /ç/, /x/, /θ/ and /f/. The following vowel had also a significant effect on frication duration ($F(4)=13.258$, $p<0.001$) (fricatives before i u > e o > a).

Regarding spectral mean, a similar 3-way Anova revealed a main effect of age ($F(2)=14.459$, $p<0.001$), with significantly higher values for children than the adult groups. Subsequent tests for each fricative revealed significant differences between children and adults for the fricatives /θ/, /s/, and /x/. A main effect was also revealed for place of articulation ($F(4)=67.979$, $p<0.001$), with /s/ having the highest value followed by /ç/, /θ/, /f/, /x/ and all differences being significant except for the one between /θ/ and /f/.

In the 3-way Anova with spectral variance as the dependent variable, a main effect of the age was revealed ($F(2)=3.260$, $p=0.039$), with the age groups 3-6 and 53-56 having significantly higher values than the group 23-26. Subsequent tests for each fricative revealed significant differences between the children and the adult groups for the fricatives /θ/ and /s/. A main effect was also revealed for place of articulation ($F(4)=109.874$, $p<0.001$). /s/ had the lowest values

followed by /ç/, /x/, /θ/, /f/. Significant differences were revealed between /s/ and /f/, /θ/, /x/, and between /ç/ and /θ/, /x/.



Figures 1-3. Duration (ms), spectral mean and variance (Hz) of Greek voiceless fricatives as produced by children 3-6 and adults 23-26 and 53-56 years old.

According to 2-way ANOVAs within each age group, duration did not differentiate fricatives in children group, though it significantly differentiated /s/ from /f/, /θ/, and /x/ in both adult groups. Spectral mean significantly differed among all fricatives (except for /f/-/θ/) for the adults, while for children it significantly differentiated /f/ from all other fricatives, /θ/ from /s/, /x/, /s/ from /ç/, /x/, and /ç/ from /x/. Variance differentiated the front fricatives /f/ and /θ/ from all other fricatives in all age groups (except for /θ/ from /x/ in children). Hierarchical structure of fricatives as well as with respect to each vowel were similar for the different age groups for all variables.

Table 1. Mean duration (ms), M1 and M2 (Hz) values per fricative for the three age-groups (3-6, 23-26, 53-56 years old).

Fricative	Duration			M1			M2		
	3-6	23-26	53-56	3-6	23-26	53-56	3-6	23-26	53-56
f	158	130	124	4034	3461	3399	1924	2104	2068
θ	165	130	126	5171	4030	3259	1754	2036	2024
s	175	149	145	5978	5586	5506	1278	890	990
ç	169	139	136	5295	5244	4289	1040	1156	1265
x	166	130	127	2235	1508	1780	1446	1034	1557

Discussion and conclusions

Overall, the results indicate significant temporal differences in fricative production between young children and adults as well as differences in spectral mean and variance.

In terms of duration, fricatives produced by children were significantly longer than those produced by adults. However, according to Nissen and Fox's (2005) research on English fricatives, although English speaking adults present shorter durations than children in /f/ and /θ/ productions, this changes for the alveolar and palato-alveolar fricatives, with children exhibiting shorter

durations. Moreover, duration values of Greek speaking children were not found to differentiate fricative place of articulation, which is not the case neither for Greek adult speakers (Nirgianaki 2014) nor for English speaking adults and children (Jongman et al. 2000; Nissen & Fox, 2005).

Fricatives produced by children also exhibited higher spectral mean values than those produced by adults; however, this has not been observed for the respective English fricative categories (Nissen & Fox 2005). Children's variance values were higher for /θ/ and /s/, revealing a more diffused spectrum for these fricative productions compared to the ones of adult speakers.

By confirming the existence of significant differences between children and adults in Greek fricative productions, the present study provides support to the argument that the immaturity of children's anatomical structures and motor control of vocal organs could be responsible for them (Vorperian et al. 2009). Furthermore, the accordance between the intra-category acoustic patterns of children and adult productions, as well as differences between the present results and previous ones reported for English similar sounds (Nissen & Fox 2005), support further the claim that children 'are attuned to language-specific relevant acoustic dimensions in mastering speech production' (Li 2012).

References

- Bernthal, J.E., Bankson, N.W., Flipsen, P. 2018. Φωνολογικές και Αρθρωτικές Διαταραχές. Επιμ. Παπαθανασίου, Η. εκδόσεις Κωνσταντάρας.
- Boersma, P., Weenink, D. 2019. Praat: doing phonetics by computer [Computer program]. Version 6.0.50.
- Jongman, A., Wayland, R. & Wong, S. 2000. Acoustic characteristics of English fricatives. *J Acoust Soc Am*, vol.108, n.3, pp.1252–1263.
- Li, F. 2012. Language-specific developmental differences in speech production: A cross-language acoustic study. *Child Development*, vol.83, n.4, pp.1303–1315.
- Nirgianaki, E. 2014. Acoustic characteristics of Greek fricatives. *J Acoust Soc Am*, vol.135, n.5, pp. 2964 – 2976.
- Nissen, S. L. & Fox, R. A. 2005. Acoustic and spectral characteristics of young children's fricative productions: A developmental perspective. *J Acoust Soc Am*, vol.118, n.4, pp.2570–2578.
- Nittrouer, S., 1995. Children learn separate aspects of speech production at different rates: Evidence from spectral moments. *J Acoust Soc Am*, vol.97, n.1, pp.520-530.
- Syrika, A., Nicolaidis, K., Edwards, J. & Beckman, M.E. (2011). Acquisition of initial /s/-stop and stop-/s/ sequences in Greek. *Lang. Speech* 54(3), 361-386.
- Vorperian, H. K. & Kent, R. D., 2008. Vowel Acoustic Space Development in Children: A Synthesis of Acoustic and Anatomic Data. *J Speech, Lang Hear Res*, December, vol.50, n.6, pp.1510–1545.