

# Voice onset time of the voiceless alveolar and velar stops in bilingual Hungarian-English children and their monolingual Hungarian peers

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**Abstract.** The VOT of Hungarian voiceless stops overlaps with that of the English voiced counterparts, which may present a challenge for Hungarian-English bilinguals. This study addresses this problem by investigating the VOTs of the two most common voiceless stops in Hungarian: /t/ and /k/, which are analyzed in the speech of bilingual Hungarian-English children and monolingual Hungarian children. The research question was whether bilingual Hungarian- and English-speaking children produce the voiceless dental and velar stop VOTs similarly to their monolingual Hungarian-speaking peers? We hypothesized that (1) VOT is longer in the speech of bilingual children when they speak Hungarian compared to their monolingual Hungarian-speaking peers' VOTs; (2) This difference is observed regardless of the type of speech in initial position in a picture naming test versus in spontaneous narratives; (3) The speech task highly influences VOTs. Ten bilingual Hungarian-English children (mean age: 6;6) and 10 monolingual Hungarian children (mean age: 6;6) participated in the study. A single-word picture naming task was used to elicit word-initial singleton stops in stressed position. Children were also asked to talk about school or free time, prompting narratives from which 10 /t/ and /k/ phonemes in CV position were selected for VOT analysis. PRAAT 5.0 was used to analyze the VOT values of word-initial, singleton, stressed /t/ and /k/ phonemes from both the picture elicitation task and the narrative. Results showed that bilingual children's VOTs are longer than those of their monolingual peers in the case of /k/, irrespective of the type of task; but there is no significant difference between the two groups in the case of /t/. There is also a statistically significant difference between the two types of speech tasks. Our findings indicate that bilingual Hungarian-English-speaking children produce their voiceless stops differently from their monolingual peers, and there is also a task effect.

**Keywords:** voiced onset time, voiceless stops, bilingual and monolingual children

## Introduction

Voice onset time (VOT) is the duration between the burst and the onset of voicing of the next voiced segment (Lisker & Abramson, 1964; Lieberman & Blumstein, 1988). VOT values differ from one language to the other (Lisker & Abramson, 1967; Cho & Ladefoged, 1999). Languages of the world can be divided into several groups based on the VOTs of their stops (Lisker & Abramson, 1964). There are languages in which stops can be divided into three or four groups (Lisker & Abramson, 1964; Gandour & Dardarananda, 1984), while for example in Hungarian there are two categories of stops: voiced and voiceless ones (Lisker & Abramson, 1964; Gósy & Ringen, 2009). VOTs of voiceless stops can be aspirated or non-aspirated. In languages with aspirated stops like English (Torre & Barlow, 2009), VOTs are longer than in languages with non-aspirated stops like in Hungarian (Gósy & Ringen, 2009).

Voiced and voiceless stop consonant contrasts vary in terms of voice onset time (VOT) across different languages, which may pose challenges for bilinguals who learn languages that differ in this respect. Several studies examined VOT in bilingual children's speech production, and they found cross-language influence in bilingual phonological acquisition (e.g., Fabiano-Smith & Barlow, 2009; Fabiano-Smith & Goldstein, 2010; Fabiano-Smith & Bunta, 2012).

Hungarian-English bilinguals are faced with the problem of learning two languages that differ in how voiced and voiceless stops are distinguished based on VOT, because Hungarian has a voicing lead for

voiced stops and a short lag for their voiceless counterparts, while English voiced stops tend to have a short lag while voiceless stops have a long lag (VOT). Consequently, the VOT of Hungarian voiceless stops overlaps with the English voiced counterparts, which may present a challenge for Hungarian-English bilinguals.

This study addresses the above-named problem by investigating the VOTs of the two most common voiceless stops in Hungarian: /t/ and /k/, which are analysed in the speech of bilingual Hungarian-English children and monolingual Hungarian children. In Hungarian, the acquisition of stops by monolingual children doesn't finish by the age of 13 years old, at which age /t/ VOTs differ from those in adults (Bóna & Auszmann, 2014). However, the VOTs of /k/ were similar to the values measured in adult speech at the age of 9 (Bóna & Auszmann, 2014). In this study, we investigate the VOTs of 6-7-year-olds whose language acquisition has not finished.

The research question was the following: Do bilingual Hungarian- and English-speaking children produce voiceless alveolar and velar stop VOTs in a similar fashion to their monolingual Hungarian-speaking peers? We hypothesize that (1) VOT will be longer in the speech of bilingual children when they speak Hungarian relative to their monolingual Hungarian-speaking peers' VOTs. (2) This difference will be observed regardless of the type of speech, whether the examined consonants are produced in initial position (in a picture naming test) or in spontaneous narratives. (3) However, the speech task will influence highly VOTs in both bilingual and monolingual speech. Our hypothesis concerning the influence of the speech task is based on the fact that the linguistic environment is more controlled in the case of a single-word picture naming test than in conversational speech, when children listen to the content more than on the form. Therefore, we hypothesize that VOT will be longer in the initial stressed positions of the picture naming task than in spontaneous speech.

## Methods

### Participants

Participants were chosen for the research following the Hungarian ethical regulations. 10 Hungarian-English bilingual children (mean age: 6;6) and 10 Hungarian-speaking monolingual children (mean age: 6;6) participated in this study. All participants have normal hearing and none of them show any cognitive, speech or language disorders based on school evaluation. All bilingual children live in Hungary and have studied at an American school in Budapest, Hungary for two years (K and grade 1). Their parents (or at least the mother) are Hungarian and their first language is Hungarian. All Hungarian-speaking monolingual children attend public elementary schools in the capital and none of them have learned foreign languages so far.

### Material

All participants were tested individually. The recordings were made in a quiet room of the school using a Zoom H4 recorder. We investigated the speech of the children under two conditions. The first condition was a single-word picture naming test. It was only a part of a bigger picture naming test. The following words were used for this test:

<b>words with /t/:</b>	<i>teknős</i> (turtle), <i>telefon</i> (telephone), <i>templom</i> (church), <i> toll</i> (feather)
<b>words with /k/:</b>	<i>kabát</i> (coat), <i>kacsa</i> (duck), <i>kalap</i> (hat), <i>kalapács</i> (hammer), <i>kecske</i> (goat), <i>kés</i> (knife), <i>kéz</i> (hand), <i>könyv</i> (book), <i>kukac</i> (worm), <i>kút</i> (well), <i>kutya</i> (dog)

In this task singleton /t/ and /k/ phonemes in word-initial, stressed position were selected for VOT analysis.

The second condition was a spontaneous speech task. Children were asked to talk about school life or free time activities. In this case of conversational narratives, we investigated the plosives in CV positions.

## Method

The segmentation of the VOT values of /t/ and /k/ phonemes and measurements were conducted using Praat 5.3 (Boersma & Weenink, 1998). The recordings were annotated by two of the authors while the third one controlled and checked annotations. In this study, voice onset time was defined as the time span between the beginning of the burst and the absolute onset of voicing as observed on the oscillogram and on the spectrogram in parallel (Beckman et al., 2011).

Statistical analyses (UNIANOVA, repeated-measures ANOVA, Mann-Whitney *U*-test, Wilcoxon-test) were carried out by SPSS 20.0. The dependent variables were (1) all data and (2) the average duration of /t/ and /k/ per child per task. Independent variables included language status and speech task.

## Results

### The picture naming task

First, we examined the average duration of /t/ and /k/ sounds per child, which meant 10 samples per group. Comparing the average VOT of these Hungarian voiceless stops produced by bilingual students to their monolingual peers' VOT, the statistical analysis did not show significant difference ( $p > 0,05$ ). However, data showed a tendency that bilingual children aspirate the examined stops to a greater extent than their monolingual peers (Figure 1).

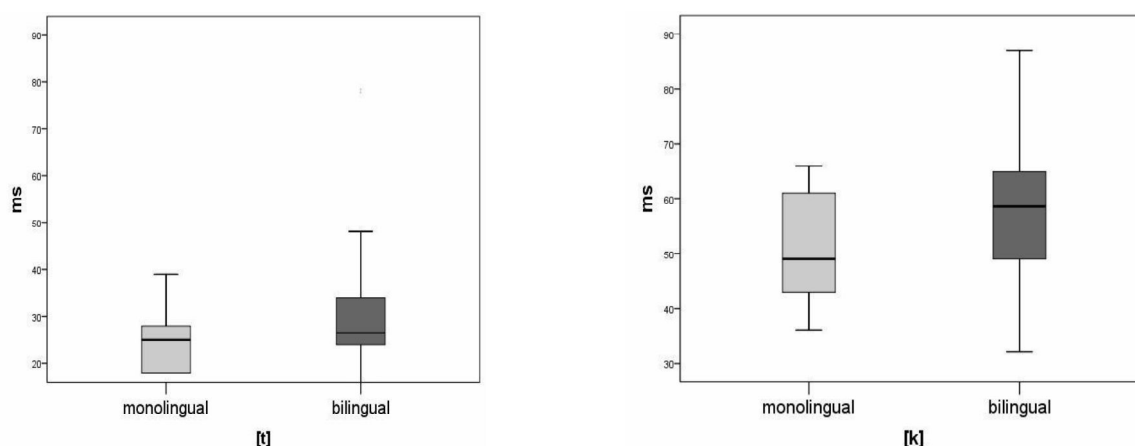


Figure 1. The comparison of average VOT of Hungarian /t/ and /k/ stops by monolingual and bilingual children

Secondly, we used all data in both groups: in the case of stop /t/ it meant 40, in the case of stop /k/ it meant 110 samples. This time, statistical difference was revealed between the bilingual and the monolingual groups in the duration of the voiceless stop /k/ ( $Z = -2,904$ ;  $p = 0,004$ ). However, in the case of sound /t/, statistical difference could not be detected. The tendency of the more aspirated pronunciation in the bilingual group is shown in Figure 2.

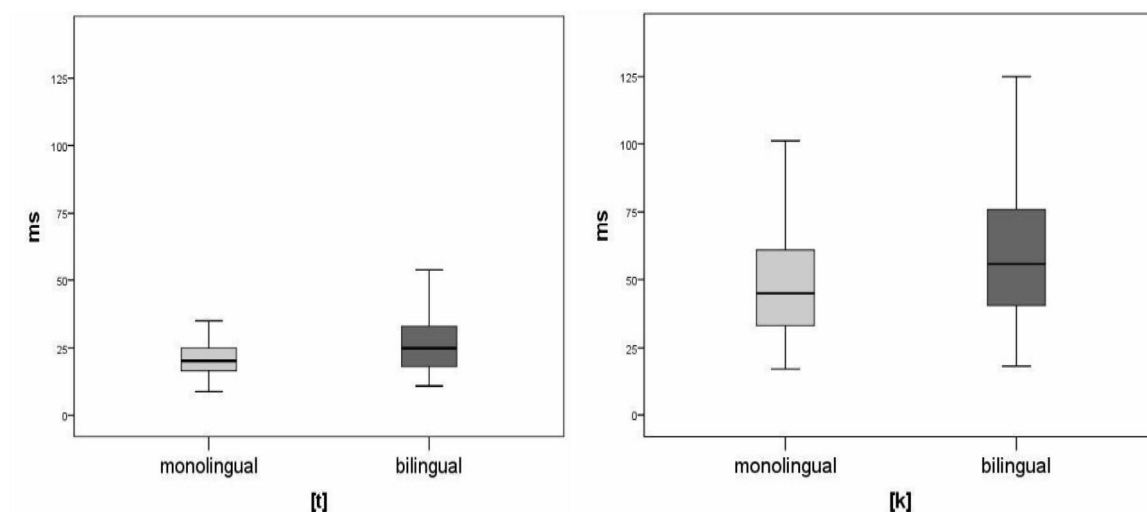


Figure 2. The comparison of all VOT data of Hungarian /t/ and /k/ stops by monolingual and bilingual children groups

### Spontaneous speech

When we examined the average duration of /t/ and /k/ sounds per child in spontaneous speech gaining from 80 /t/ and 140 /k/ sound items, we did not find significant difference in the case of /t/ sound. On the other hand, the bilinguals' pronunciation of the Hungarian sound /k/ was significantly longer than that of their Hungarian monolingual peers:  $F(1, 19) = 4,830$ ;  $p = 0,041$ ;  $\eta^2 = 0,212$  (figure 3).

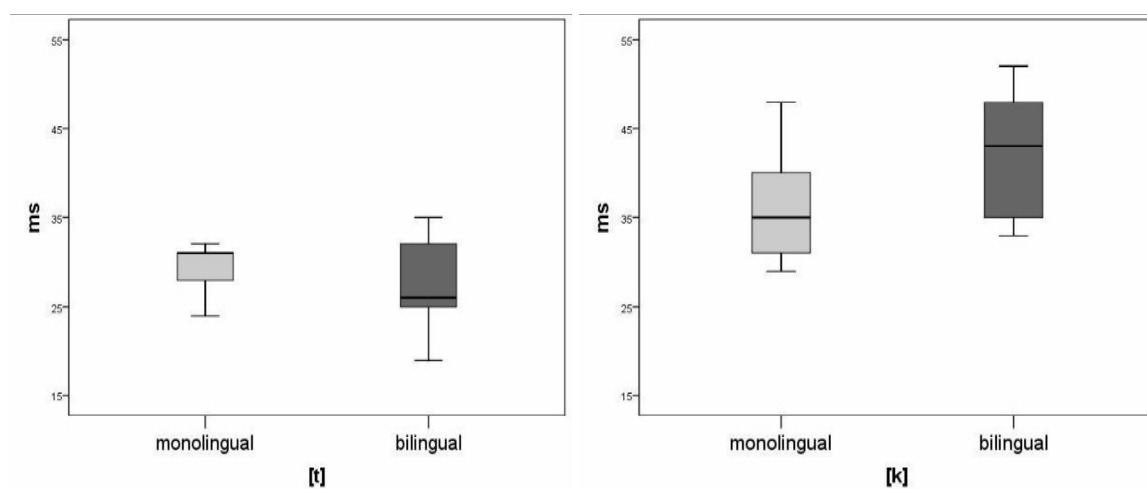


Figure 3. The comparison of average VOT of Hungarian /t/ and /k/ stops in spontaneous monolingual and bilingual speech

We further examined the two groups' spontaneous speech and we found that using all data in the statistical analysis confirmed the previous result (Figure 4): no significant difference was detected in the duration of /t/ sound between the bilingual and the monolingual pronunciation, while bilingual children pronounced the /k/ sound significantly longer, i.e. with aspiration, than their monolingual peers:  $Z = -3,970$ ;  $p < 0,001$ .

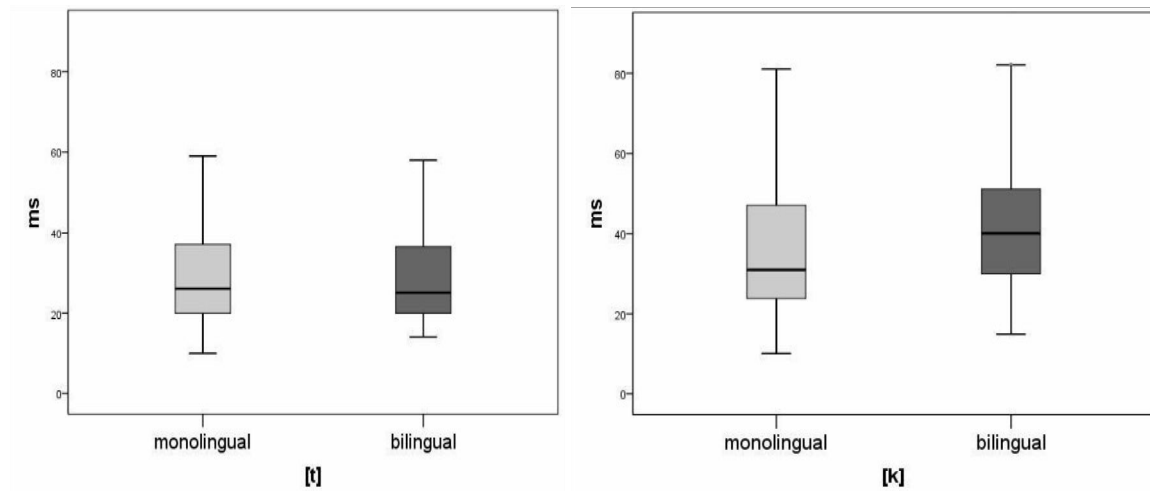


Figure 4. The comparison of all VOT data of Hungarian /t/ and /k/ stops in spontaneous monolingual and bilingual speech

### The effect of the speech task

Comparing the length of the VOT of the examined voiceless stops in the two different speech tasks, namely in the picture naming test and the spontaneous speech, we found no significant difference in the case of /t/, but the VOT of the /k/ sound was significantly longer in children's utterances in the picture naming task than when they uttered this sound in spontaneous speech (Figures 5 and 6). It was true for both monolingual ( $F(1, 19) = 17,895$ ;  $p = 0,001$ ;  $\eta^2 = 0,499$ ) and bilingual ( $F(1, 19) = 6,418$ ;  $p = 0,021$ ;  $\eta^2 = 0,263$ ) groups. At the same time there were big individual differences.

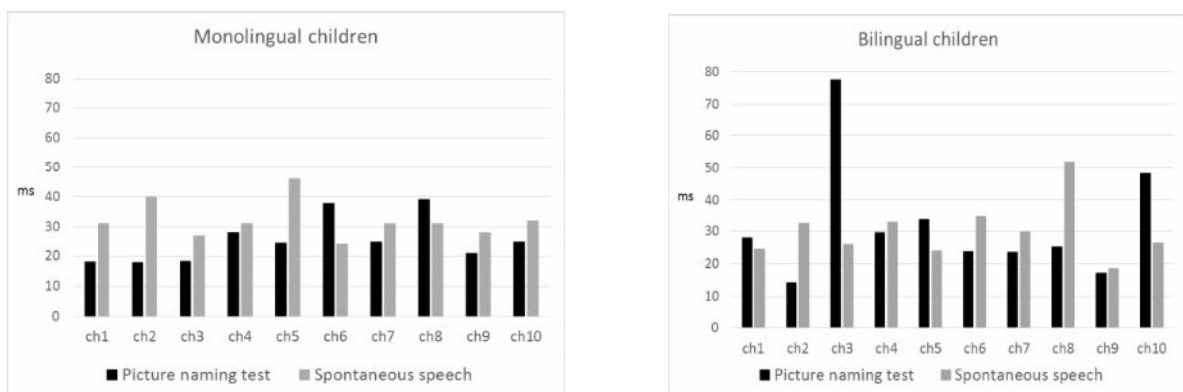


Figure 5. The effect of speech tasks: the average duration of /t/ per child in the monolingual and the bilingual groups

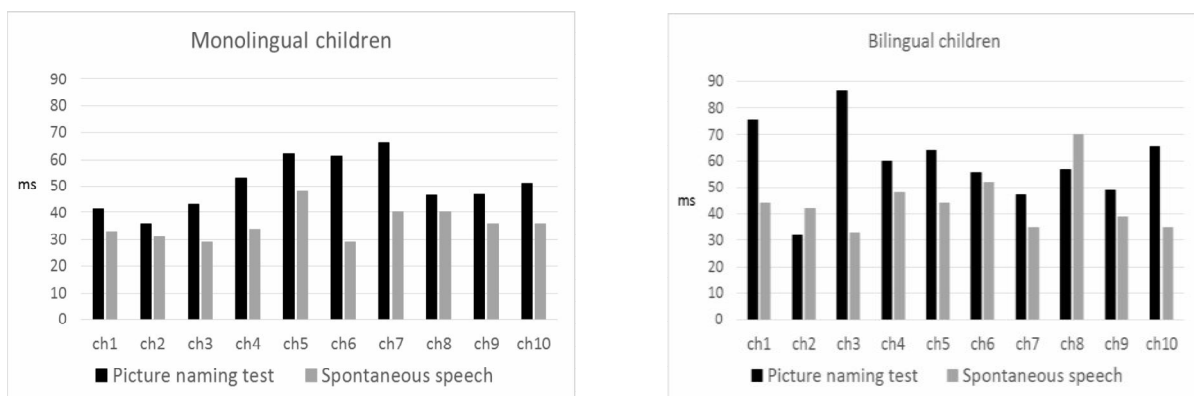


Figure 6. The effect of speech tasks: the average duration of /k/ per child in the monolingual and the bilingual groups

Interestingly, the alveolar stop showed the opposite tendency, namely children articulated the /t/ sound longer in the spontaneous speech, though the difference was not significant.

## Discussion

Our hypotheses concerning the length of VOTs were confirmed partially. The VOTs of /k/ were significantly longer in the speech of bilingual children when they spoke Hungarian comparing them to their monolingual Hungarian-speaking peers' VOTs. However, the difference was not significant in the case of /t/ sound. We assume that our results are the effect of the following possible factors in our examination, namely:

- a. It could be the result of the fewer /t/ VOT values in the sample. Almost three times more /k/ than /t/ sound could be gained from the picture naming test, and the ratio of /t/ and /k/ sounds was 4/7 in the spontaneous speech.
- b. Children acquire the /t/ sound earlier, therefore they have used it in the Hungarian pronunciation for a longer period than the /k/ sound before their encounter with the native American articulation of these sounds.

Further, we expected that the difference between the bilingual and the monolingual pronunciation would be observed both in the case of the picture naming test and in the samples of spontaneous narratives. Our hypothesis was confirmed in the case of the voiceless stop /k/ when *all data* were considered. We did not find significant difference during the statistical analysis of the *average duration of the VOT per child* situation in the picture naming test which might be due to the fewer samples. In the case of the dental stop, significant difference in the VOT of the bilingual and the monolingual pronunciation could not be detected in either of the speech tasks. Our argument concerning this result was explained in the previous paragraph.

Our third hypothesis, that the speech task influences VOT was confirmed in the case of the velar stop /k/. Both bilingual and monolingual children articulated the VOT of these Hungarian voiceless stops longer in the case of clear initial position than in spontaneous speech, where the syllable which contained the examined sound was not stressed. We argue that the same result could not be detected in the case of the voiceless stop /t/ because its phonological features in the given picture naming test were less diverse than those of the /k/ sound. However, in the case of the /k/ sound, with an optimal variety of the phonological features, the results clearly showed that speech task highly influences VOT.

## Conclusion

The present research provided first data concerning the effect of bilingualism on the VOT duration in the case of /k/ and /t/ voiceless stops in Hungarian. It clearly demonstrated that bilingualism exercises influence on the VOT in the case of the Hungarian pronunciation. Monolingual children at the age of 6 articulate the /k/ sound with less aspiration than their bilingual peers whose first language is Hungarian. In future research, there should be more control over the sample size to gain more reliable information about how bilingualism might affect the VOT of the examined sounds. Further research may focus on the analysis of the VOT of these stops in English, the bilingual children's other language and compare the results to their Hungarian pronunciation. Overall, the present research provides novel information for bilingual child language and serves as a foundation for further research.

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