Effect of Place of Articulation on VOT of Syrian EFL Students

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Abstract

The aim of this paper was to investigate the effect of place of articulation (PoA) of English voiceless plosives /p, t, k/ on Voice Onset Time (VOT) of Syrian EFL students. Sixty undergraduate students from the Department of English at Aleppo University participated in this study. They were asked to produce the voiceless plosives /p, t, k/ in word-initial stressed position followed by both high and low vowels. The target words were recorded and then measured using the speech analysis software of "PRAAT" in order to verify their VOT values. The obtained results were also statistically analysed using a One-Way Analysis of Variance (ANOVA) test and a Sidak test. The results of the statistical analysis indicated that the difference in VOT values obtained for the three plosives reached significance. This conforms to the general consensus and similar results observed in previous studies which state that the further back the PoA the longer the VOT values. It was also found in this study that the mean VOT values of /p/ and /t/ did not reach significance. Overall, results showed that PoA played a fundamental role in determining VOT values.

Keywords: VOT, PoA, ANOVA, Sidak.

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تأثير مكان النطق على زمن بدء الجهر لدى الطلبة السوريين متعلمي اللغة الإنكليزية بوصفها لغة أجنبية

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الملخص

تحرت هذه الدراسة تأثير مكان نطق الأصوات الانفجارية المهموسة التالية /p, t, k/ على زمن بدء الجهر لدى الطلبة السوريين متعلمي اللغة الإنكليزية بوصفها لغة أجنبية. و شملت هذه الدراسة ستين طالباً من قسم اللغة الإنكليزية في جامعة حلب. تم وضع هذه الأصوات قبل الصوائت المشددة المرتفعة و المنخفضة في أول الكلمة وطلب منهم قراءتها. تم تسجيل القراءات وقياسها باستخدام برنامج تحليل الأصوات PRAAT كما تم تحليلها إحصائيا باستخدام اختبار تحليل التباين أحادي الاتجاه One-Way ANOVA واختبار Sidak لدراسة الفروق المعنوية الثنائية. بيّن التحليل الإحصائي أن هناك فرقا" مهما" بين قيم زمن بدء الجهر للأصوات الثلاثة وهذا يتطابق مع الدراسات السابقة التي تشير إلى أن قيم زمن بدء الجهر تزداد كلما ازداد مكان الصامت قرباً من الحنك الرخو وبعداً عن الشفتين. كما أظهرت الدراسة أنه لا يوجد فرق" مهم" بين قيم زمن بدء الجهر للصوتين /p/ و /t/ . وخلصت هذه الدراسة إلى أنّ مكان نطق الأصوات قيد الدراسة ذو دور رئيس في تحديد قيم زمن بدء الجهر.

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1. Introduction

English plosives have three different places of articulation: bilabial /p, b/, alveolar /t, d/, and velar /k, g/. To produce these plosives, air coming from the lungs is temporarily blocked at some point of the oral tract, due to the contact between the articulators. During this period, no sound is produced and a short period of silence can be perceived. After this moment, the articulators come apart and the airstream is finally released, causing a turbulent noise, which is called explosion. If the sound produced is a voiced plosive, the vibration of the vocal folds starts either before or at the moment of the release of the obstruction. However, if it is a voiceless plosive, no vibration is observed until the production of the next or following segment [1].

The temporal interval between the release of the closure or constriction of the plosive and the onset of vocal fold vibration for the following vowel is known as VOT [2-3-4-5]. If voicing begins during the occlusion phase or earlier, VOT is negative and called "voicing lead". If voicing begins after the plosive release or later, VOT is positive and called "voicing lag". If voicing begins at the moment of the plosive release, VOT is zero [4].

Aspiration in English, which is traditionally defined as a period of voicelessness, corresponds to long lag VOT [6]. When there is a considerable delay in VOT measurement, aspiration tends to be present. It is essentially a delay in the onset of voicing of the following vowel.

Unlike aspiration, VOT values can be measured in milliseconds (ms). The values are not absolute; they are rather influenced by several different factors. VOT values are usually longer in one-syllable words than in two-syllable words [3]. In addition, VOT values are longer in stressed syllables than unstressed ones [7]. Another factor to influence VOT values of voiceless plosives is PoA. The majority of studies, which have dealt with variation in VOT values in English, have studied the influence of this factor [2-3-8-9-10-11-12]. The results of these studies show that VOT values increase as the place of articulation moves from anterior to posterior position in the vocal tract, i.e. from bilabial to alveolar and then to velar.

In a cross-language study of VOT, it was found that in English the average VOT values for voiceless plosives were as follows: 58 ms for /p/, 70 ms for /t/, and 80 ms for /k/ [2]. In another study, it was found that the mean VOT values in word-initial position were 37 ms for /t/ and

52 ms for /k/ [10]. In a cross-linguistic study of the relation between VOT and place of articulation, it was stated that some physiological and aerodynamic factors might explain the variations in VOT values associated with a difference in the place of articulation, such as the volume of the cavity behind and in front of the point of constriction, the movement of the articulators, the extent of the articulatory area, the changes of the glottal opening area, and the temporal adjustment between closure duration and VOT [9].

The aim of this study was to examine the effect of PoA on VOT values obtained by Syrian EFL students at Aleppo University. It is intended to provide information concerning VOT values of English voiceless plosives /p, t, k/ in word-initial stressed position.

2- Method

2-1- Participants

Sixty undergraduate students; 30 Males (M) and 30 Females (F) participated in this study. They were divided into two groups according to their proficiency level. The first group of participants (15 M and 15 F) were chosen randomly from the population of the first year students, whereas the second group of participants (also 15 M and 15 F), were selected at random from the population of the second year students.

2-2- Speech stimuli

A list of 24 words were collected and used as speech stimuli in this study. These words contained the voiceless plosives /p, t, k/ in initial position of stressed syllables. These plosives were followed by eight English high and low vowels /iː, ɪ, ʊ, uː, æ, ʌ, ɑː, ɒ/. This resulted in the following combinations: 'bilabial plosive+ high vowel (HV)' as in: *peel, picture, put,* and *pool*, 'bilabial plosive+ low vowel (LV)' as in *pack, pump, part,* and *policy*, 'alveolar plosive+ HV', as in the words: *team, ticket, took,* and *tooth*, 'alveolar plosive+ LV', as in: *tank, tongue, target,* and *top*, 'velar plosive+ HV', as in: *key, king, cook,* and *cool*, and finally 'velar plosive+ LV', as in: *cat, come, card* , and *complex*. The participants were asked to read each word three times at a normal speaking rate. A total of 4320 tokens (3 repetitions × 24 words × 60 participants) were acoustically analysed.

2-3- Instruments used

All recordings were made in a language lab at Aleppo University. The type of recording was Mono with a sampling frequency of 5000 Hz. The microphone was positioned at a distance of 15 cm from

the mouth of the participant. The list of words were typed and presented to the participants on Index Cards. Each sample was recorded, measured and analysed by using PRAAT [13].

2-4- Measurements and data analysis

As mentioned in previous studies [2-3-4-5-6], VOT has been defined as the time interval between the articulatory release of the plosive and the onset of vocal fold vibration. It is just a duration measurement between two points. To measure VOT, a number of steps were followed: (1) finding the plosive release, (2) finding the start of voicing, (3) selecting the span between the two points, and (4) reading the duration of the selection (in ms) from the duration bar along the bottom of the editor window of PRAAT [13]. VOT values of the voiceless plosives were obtained from waveform display and verified with spectrogram display. On the waveform, VOT value is obtained from the time interval between the release spike and the start of the oscillating line, which is an indication of vibration of the vocal folds. On the spectrogram, VOT is measured from the release spike to the start of the formants of the following vowel, as shown in Figure 1.

2-5- Statistical analysis

An SPSS statistical software was used in this study for descriptive and inferential statistical analysis. Measures of central tendency, such as the Mean (M) and Standard Deviation (SD) of obtained VOT values were calculated. A One-Way ANOVA and a Sidak test were also used to test whether the difference in VOT values between groups reached significance. The One-Way ANOVA was used to compare the means of VOT values regarding the PoA variable. Sidak test was used to test the statistical significance between pairs. An alpha level of 0.05 was set as the level of significance.

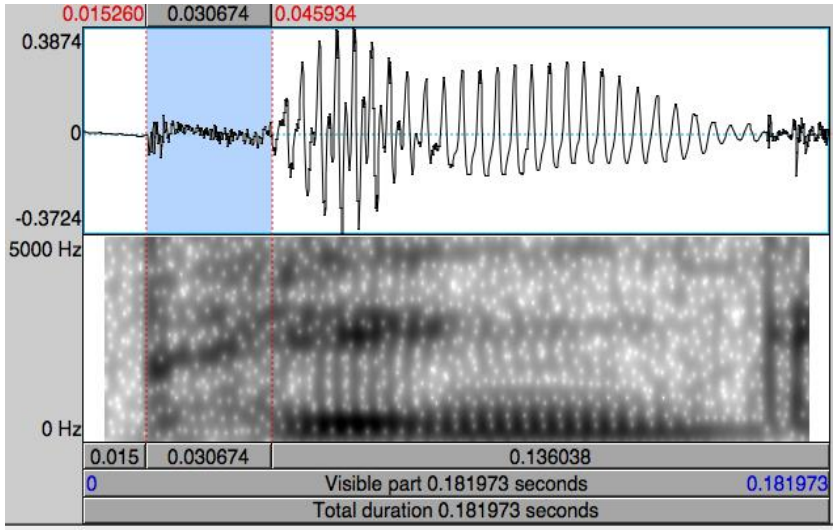

Figure 1 Measurement of VOT value (in ms) for the voiceless bilabial plosive /p/ in the word *pink* using the PRAAT editor window display

3- Results and discussion

The statistical analysis of VOT values for both groups of participants were included. The Mean VOT values for both groups of participants, together with their Standard Deviation and Range are presented in Table (1).

Table (1) Mean VOT values, SD and Range for voiceless plosives produced by the two groups of participants

PoA	Mean	SD	Range	
Group 1			Min	Max
/p/+HV	21.0250	11.46405	6.77	40.67
/t/+HV	33.1875	11.31775	21.46	50.47
/k/+HV	48.8463	10.50025	29.04	62.80
/p/+LV	10.5450	2.47014	6.68	14.28
/t/+LV	17.6263	1.50680	14.73	19.11
/k/+LV	32.7988	5.33812	24.41	41.18
Group 2				
/p/+HV	20.3612	7.29142	8.13	29.42
/t/+HV	30.3325	9.54365	22.23	50.64
/k/+HV	47.2600	7.69813	34.56	56.70
/p/+LV	13.1500	2.86238	8.51	16.42
/t/+LV	18.3400	2.51916	15.48	22.00
/k/+LV	39.4025	5.56312	8.51	46.98

VOT values tend to correlate with plosives' PoA; the more posterior a plosive's PoA, the longer VOT values will be [2-3-8-9-10-11-12]. This tendency is confirmed in this study. Table (1) clearly shows

that the mean VOT values of velar plosives were longer than those of alveolar plosives, which, in turn, had longer VOT values than those of bilabial plosives.

The One-Way ANOVA showed a statistically significant difference in VOT values obtained for the three plosives /p, t, k/ when followed by high vowels in the production of the first group of participants (F = 12.626; p = .000 < 0.05). The results also showed statistically significant difference in VOT values when the same plosives were followed by low vowels (F = 84.148; p = .000 < 0.05). Figures (2), (3) and (4) show the mean VOT values of the three voiceless plosives when followed by high and low vowels for the two groups.

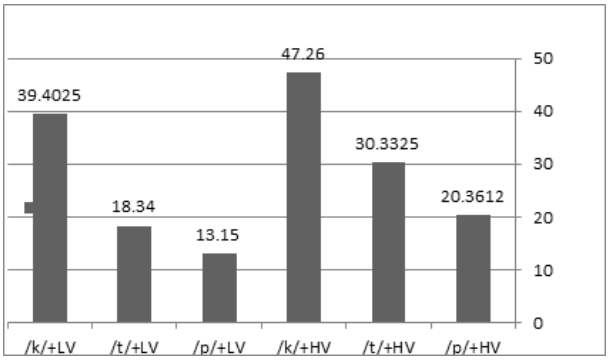

Figure (2) VOT values (in ms) of the voiceless plosives /p, t, k/ followed by high and low vowels for the first group

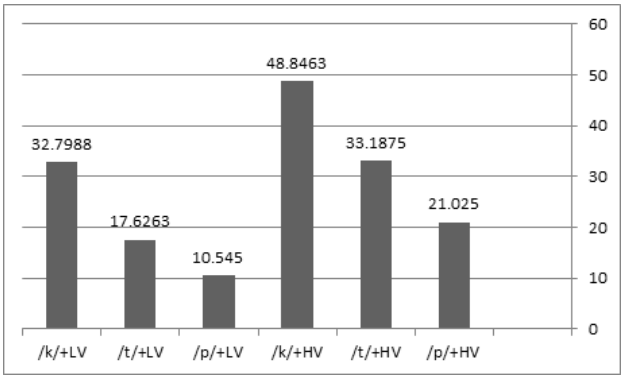

Figure (3) VOT values (in ms) of the voiceless plosives /p, t, k/ followed by high and low vowels for the second group

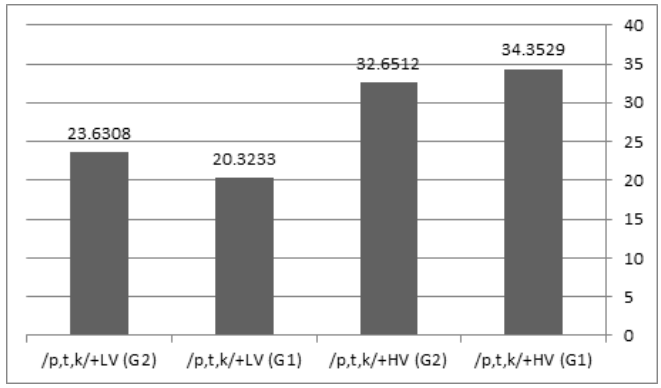

Figure (4) MeanVOT values (in ms) of the voiceless plosives /p, t, k/ followed by high and low vowels for both groups

As for the second group of participants, results were also highly significant for the plosives produced: for plosives followed by high vowels (F= 21.808; p = .000 < 0.05) and for plosives followed by low vowels (101.984; p = .000 < 0.05). Table (2) shows the mean VOT values, standard deviation, F, and the statistical significance (p) for plosives produced by the two groups:

Table (2) Mean VOT values, SD, F, and Statistical Significance of plosives followed by high and low vowels for both groups

PoA	M	SD	*F*	Sig.
/p,t,k/+HV (G1)	34.3529	15.74368	12.626	**.000**
/p,t,k/+HV (G2)	32.6512	13.80492	21.808	**.000**
/p,t,k/+LV (G1)	20.3233	10.05697	84.148	**.000**
/p,t,k/+LV (G2)	23.6308	12.17821	101.948	**.000**

Sidak test showed that /p/ and /t/ in both contexts produced by the two groups did not differ significantly regarding VOT values (p > 0.05). However, VOT values for /k/ were significantly longer than those for both /p/ and /t/. Table (3) shows the *p*- value of the pairs of plosives followed by high and low vowels for both groups of participants.

Table (3) Statistical significance of the difference in VOT values of pairs of plosives followed by high and low vowels

Group 1					
[p-t]+HV	[p-k]+HV	[t-k]+HV	[p-t]+LV	[p-k]+LV	[t-k]+LV
.115	**.000**	**.030**	.52	**.000**	**.000**
Group 2					
[p-t]+HV	[p-k]+HV	[t-k]+HV	[p-t]+LV	[p-k]+LV	[t-k]+LV
.72	**.000**	**001**	.53	**.000**	**.000**

Differences in VOT values can be attributed to three reasons: (a) the absence of the sound /p/ from the Arabic sound inventory, (b) the approximation of the Mean VOT values of the sounds /p/ and /t/, and (c) the closeness of articulatory positions for both plosives [14].

The findings of this study confirm partially the effect of PoA factor on VOT values. The findings also accord with those of previous studies [2-3-8-9-10-11-12]. As reported by [9], variations in VOT values obtained could be ascribed to a number of factors such a) the volume of the cavity behind and in front of the point of constriction, b) the movement of the articulators and c) the extent of the articulatory area, d) the changes of the glottal opening area which decreases more rapidly for alveolar or bilabial plosives than for velar ones because of the intraoral pressure, and finally e) the temporal adjustment between closure duration and VOT; when closure is longer, VOT is shorter.

4- Conclusion

In conclusion, the results of this study could be explained with reference to some physiological and aerodynamic factors. What is really important is that Syrian EFL students at Aleppo University follow the same VOT pattern of native English speakers. This implies the effect factor of PoA is a universal rather than a language-specific phenomenon and that can be noticed in different languages of the world. Even though the difference in VOT values between /p/ and /t/ did not reach significance, EFL students follow the general tendency that the further back the closure is made in the oral cavity, the longer the VOT value tends to be.

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