Voice Onset Time (VOT) and Vowel Duration

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Abstract

This study investigates the effects of voicing of a preceding and following plosive on the Voice Onset Time (VOT) and vowel duration. The data consist of words with CVC segments, with the four groups of samples that represent both voiced and voiceless plosives, both for the ones following and preceding the vowels. The preliminary hypothesis is that voicing of following plosives affects the length of the vowels, indicated by the vowel duration, and VOT is affected by the voicing of the preceding plosives, not the following plosives. To compare the effects of voicing on the lengths of the vowel duration and VOT, the sound files are analyzed using the Praat program.

The results of this study show that the voicing of the following plosives affects the vowel duration, while the voicing of the preceding plosives does not affect the vowel duration. The results also show that it is the voicing of the C_1 plosives that affect the VOT. The word-ending plosives do not affect the VOT of the preceding plosives.This study is on English vowel duration and VOT affected by the following and preceding stops. A further study can be done to compare the results of the effects with another language.

Keywords: *VOT, vowel duration, the Praat program.*

INTRODUCTION

This study investigates the effects of voicing of a preceding and following plosive on the Voice Onset Time (VOT) and vowel duration. The data consist of words with CVC segments, with the four groups of samples that represent both voiced and voiceless plosives, both for the ones following and preceding the vowels. The preliminary hypothesis is that voicing of following plosives affects the length of the vowels, indicated by the vowel duration, and VOT is affected by the voicing of the preceding plosives, not the following plosives. To compare the effects of voicing on the lengths of the vowel duration and VOT, the sound files are analyzed using the Praat program.

A. METHODS

a. The Data

The data consist of the following sound files:

1) Four sound files, each file consists of 8 test words. The test words are in the carrier sentence "The word is…." There is one token of each word. The words, which have the segments of CVC, have been grouped in the following categories. Here are the words in this study:
   a) $C_{[-voice]}$ V $C_{[-voice]}$: pat, pot, cot, putt, talk, puck, tuck, pick.
   b) $C_{[-voice]}$ V $C_{[+voice]}$: pad, pod, cod, pud, tog, pug, tug, pig.
   c) $C_{[+voice]}$ V $C_{[-voice]}$: bat, bought, got, but, dock, buck, duck, bic.
   d) $C_{[+voice]}$ V $C_{[+voice]}$: bad, bod, god, bud, bug, dug, big.

2) Four sound files, each file consists of one test word. There are 10 tokens of each word. The test word is in the carrier sentence "The word is…." In these four sound files, there are four test words that represent each of the 4 CVC categories, and the vowel segment is the same. In this study, the words are*tuck, tug, duck, dug*. The recording is done using the sound recorder in the Praat program, recorded as mono sound, and the sampling frequency is set at 8,000 Hz. The sound files are saved as WAV files.

b. The Analysis

The calculation of the means and standard deviation of the vowel duration and VOT is done by grouping the consonants that follow the vowels into voiced and voiceless and that precede the vowels into voiced and voiceless. In the analysis, the abbreviation of C1 refers to the first plosive in the CVC words. Also, C2 refers to the second plosives in the words.

T-tests, with the tails 2 and type 2, are performed to see the significance of the difference, using the standard $p \leq 0.05$.The VOT and vowel duration obtained from the Praat program are converted to milliseconds.

B. RESULTS AND DISCUSSION

a. The results of the first 4 sound files, 8 test words in each file, one token.

1) The means and Standard Deviations

The following tables show the means and the standard deviationsof the Vowel Duration and VOTof each set in milliseconds.

Table 1. Mean and Standard Deviation of the Vowel Duration Followed by Voiceless and Voiced Plosives

	$C\ V\ C_{[-voice]}$	$C\ V\ C_{[+voice]}$
Mean	129.05	193.85
Standard Deviation	37.21	34.42

Table 2. Mean and Standard Deviation of the Vowel Duration Preceded by Voiceless and Voiced Plosives

	$C_{[-voice]}\ V\ C$	$C_{[+voice]}\ V\ C$
Mean	153.22	169.67
Standard Deviation	55.53	39.76

The results show that the voicing of the following plosives affects the vowel duration, while the voicing of the preceding plosives does not affect the vowel duration. This is confirmed by the t-test that show the difference between the means of the following plosives that are different in voicing is 1.69 E-5 (which means 1.69×10^{-5}), so it is < 0.05. While the t-test of the vowel duration between the groups of different voicing of the preceding plosives shows that it is 0.34, which is not <0.05, so it is insignificant.

The following tables show the results of the means and standard deviation of the VOT, of different voicing of the following and preceding plosives.

Table 3. Mean and Standard Deviation of the VOT of C2 (the Word Ending) by Voiceless and Voiced Plosives

	C V $C_{[-voice]}$	C V $C_{[+voice]}$
Mean	53.76	47.51
Standard Deviation	43.56	40.80

Table 4 Mean and Standard Deviation of the C1 VOT by Voiceless and Voiced Plosives

	$C_{[-voice]}$ V C	$C_{[+voice]}$ V C
Mean	89.56	11.71
Standard Deviation	17.75	5.91

The results show that it is the voicing of the C_1 plosives that affect the VOT. The following plosives do not affect the VOT of the preceding plosives. This result is also confirmed by the test of significance of the means. The t-test of the means of the different voicing of the preceding plosives (or the C1) is 1.066E-16 (or 1.066 X 10^{-16}), which is much smaller than 0.05, and it means the difference is significant. While the calculation of the t-test of the means of the VOT of the different voicing of the following plosives is 0.68, which is not smaller than 0.05, and it means it is not significant.

b. The results of the first 4 sound files, 1 test word in each file, ten tokens.

The following two tables show the results of the data on the vowel durations for plosives of different voicing, both following and preceding them.

Table 5. Mean and Standard Deviation of the Vowel Duration Followed by Voiceless and Voiced Plosives

	C V $C_{[-voice]}$	C V $C_{[+voice]}$
Mean	96.08	211.40
Standard Deviation	16.22	34.10

Table 6. Mean and Standard Deviation of the Vowel Duration Preceded by Voiceless and Voiced Plosives

	$C_{[-voice]}$ V C	$C_{[+voice]}$ V C
Mean	151.8	152.75
Standard Deviation	61.17	68.48

The results in these sets of sound files confirm the previous results. The voicing the following plosives affect significantly the vowel duration, while the voicing of the preceding plosives does not affect it. The result of the t-test shows that the different voicing of the following plosives is 5.74E-16 (or 5.74 X 10^{-16}), which is lower than the 0.05 p value. While the t-test of the preceding different voicing of plosives is 0.96, which is higher than 0.05 p value, and so it means it is not significant.

The results of the VOT measurement show that the voicing of the preceding plosives significantly affect the values. While the following voicing of the plosives do not show significant effect on the VOT values.

Table 7 Mean and Standard Deviation of the VOT of C2 (the word ending) by Voiceless and Voiced Plosives

	$C\ V\ C_{[-voice]}$	$C\ V\ C_{[+voice]}$
Mean	34.80	37.45
Standard Deviation	24.62	18.03

Table 8 Mean and Standard Deviation of the C1 VOT by Voiceless and Voiced Plosives

	$C_{[-voice]}\ V\ C$	$C_{[+voice]}\ V\ C$
Mean	52.34	19.91
Standard Deviation	13.54	14.069

The t-test of the different groups of preceding voicing is 6.58E-09 (or 6.58×10^{-9}), which is smaller than the p value 0.05, and so it is significant. The t-test of the VOT values for different voicing of following plosives is 0.70, which is higher than 0.05, and it means it is insignificant.

All the results above show that the preliminary hypothesis, i.e. that voicing of following plosives affects the length of the vowels, indicated by the vowel duration, and VOT is affected by the voicing of the preceding plosives, not the following plosives, is proven to be correct.

Ohala (1997) in his paper compared the contemporary view of the relation between phonetics and phonology with earlier attitudes on the matter. Phonetics and phonology did not exist as separate disciplines in earlier centuries. Ohala looks at the relation between phonetics and phonology as the relation between the domains of the study, and in his opinion, phonology has to be seen as the discipline that tries to answer questions about spoken language by employing the methods, data, and theories of phonetics, as well as psychology, social sciences, history, ethology, etc.He also points out that a phonetic account of how natural sound patterns will make a convincing explanatory scenario. He mentions the common practice within phonetics of making a given measurement, such as vowel duration on multiple tokens, like the one in this lab, is evidence of the integration of phonetics and phonology and that phonology can benefit from phonetic studies.

C. CONCLUSIONS

The results of this study show that the voicing of the following plosives affects the vowel duration, while the voicing of the preceding plosives does not affect the vowel duration. The results also show that it is the voicing of the C_1 plosives that affect the VOT. The word-ending plosives do not affect the VOT of the preceding plosives.

The current study shows the standard deviations but does not discuss further the implication of the deviations. Further study can provide analysis on it.More sample words with not only voiced and voiceless plosives, but also voiced and voiceless fricatives and affricates can be taken to provide further evidence if voiced and voiceless obstruents, not only stops or plosives, have the same pattern as the results of this study. This study is on English vowel duration and VOT affected by the following and preceding stops. A further study can be done to compare the results of the effects with another language.

REFERENCES

Ohala, John J. 1997. "The Relation Between Phonetics and Phonology". *The Handbook of Phonetic Sciences*. William J Hardcastle; John Laver (ed). Oxford, UK ; Malden, Mass. : Blackwell Publishers.

Source of sound files:

Class website: http://udel.edu/~heinz/classes/2012/4-633/log.html

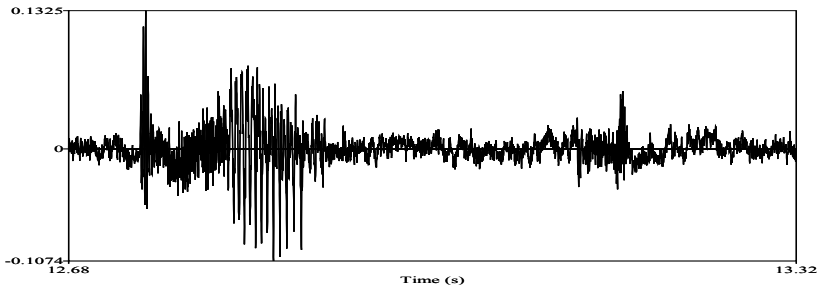
Appendix 1: The calculations of the second set of sound files

words	VOT in ms	Vowel Length in ms			
tuck1	50.3	103.3	Mean		
tuck2	52.3	122.5	VOT -voice C1	52.338	
tuck3	54.93	118.04	VOT +voice C1	19.914	
tuck4	56.1	93.49			
tuck5	51.7	100.9	Mean		
tuck6	52.91	68.29	Vowel Length		
tuck7	54.09	80.83	VL C2 –voice	96.081	
tuck8	86.49	83.34	VL C2 +voice	211.4042105	
tuck9	70.14	95.98			
tuck10	41.22	103.98	Mean		
			VOT -voice C2	34.8025	
			VOT +voice C2	37.4495	
tug1	68.28	181.2			
tug2	48.58	187.77	Standard Dev		
tug3	46.41	171.61	VOT -voice C1	13.54345155	
tug4	45.3	171.62	VOT +voice C1	14.06898358	
tug5	73.46	206.49			
tug6	32.75	195.57			
tug7	38.71	211.45	Standard Dev		
tug8	33.75	255.13	Vowel Length		
tug9	41.69	252.21	VL C2 -voice	16.22142829	
tug10	47.65	232.3	VL C2 +voice	34.09629425	
			Mean		
duck1	24.55	110.7	VL C1-voice	151.8	
duck2	8.57	81.46	VL C1 +voice	152.7526316	
duck3	11.3	99			
duck4	10.53	75.52	Stand Dev		
duck5	14.42	102.13	VOT C2 -voice	24.61633409	
duck6	7.79	108.75	VOT C2 +voice	18.02869598	

duck7	14.03	117.72			
duck8	15.98	98.61	Stand Dev		
duck9	9.35	91.99	VL C1 -voice	61.16815004	
duck10	9.35	65.09	VL C1 +voice	68.48023031	
			T Test VOT (Voicing)	6.58548E-09	significant
dug1	9.7	139.11	preceded by +-voice		
dug2	54.9	194.11	T Test Vowel length	5.73803E-16	significant
dug3	49.33	207.-5	followed by +-voice		
dug4	37.2	208.67	T Test VOT (Voicing)		
dug5	29.11	253.96	followed by +-voice	0.700205483	insignificant
dug6	8.89	200.58	T Test Vowel Length		
dug7	21.02	234.55	preceded by +-voice	0.963661394	insignificant
dug8	34.77	214.33			
dug9	12.94	236.69			
dug10	14.55	269.33			

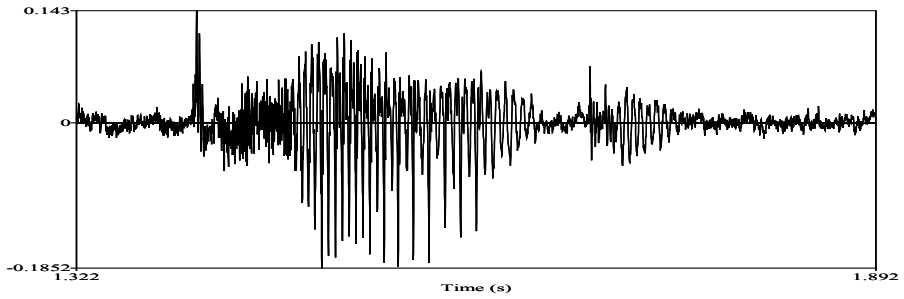
Appendix 2: Samples of the measurement of the VOT and Vowel Duration

tuck



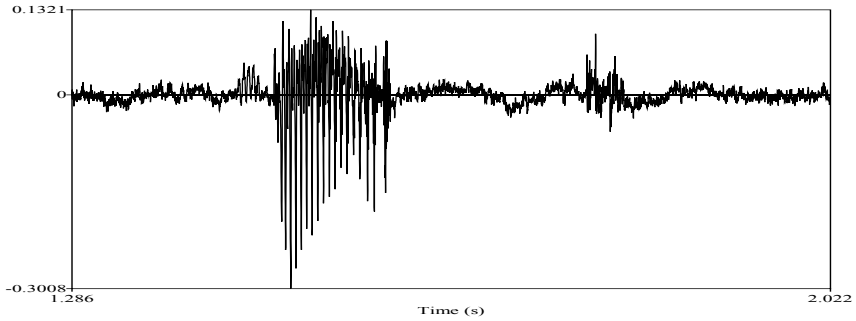
<VOT--><V Duration>

tug



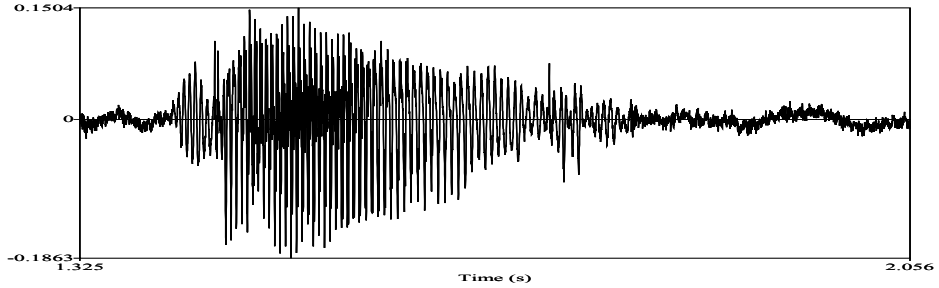
<VOT------><---------Vowel Duration--------->

duck



<VOT><Vowel Duration>

dug



<VOT><-------Vowel Duration------>