Athens Journal of Philology - Volume 2, Issue 2 – Pages 123-134

Phonetic Neutralization: The Case of Persian Final Devoicing

By Zeinab Tofigh[*]
Vahideh Abolhasanizadeh[†]

This paper aims to investigate the degree of word-final devoicing in Persian (Farsi). 9 word pairs were chosen with each word consisting of one syllable. Each word has the structure CVC, and in every pair only the phoneme for final C changes in underlying voicing and the initial CV remains unchanged. Pairs were chosen in a way to include all Persian voiced and voiceless plosives: /p , b/, /t , d/ , /k , g/, and also all three Persian long vowels: / i: / , / u: / , / a: /. Words were pronounced by 4 Persian native speakers, 2 males and 2 females, and were recorded using Praat software. Acoustic analysis focused on different measures, like: F0, F1, F2, F3, COG, VOT and duration. Results showed the absence of complete neutralization of underlying voice in this environment in Persian.

Keywords: *Neutralization, Final Devoicing, Offset, Voicing, Gender, Formants, Duration.*

Introduction

In connection with the phonological distinction between voiced sounds, which are produced when the vocal folds are vibrating, and voiceless ones when the vocal folds are apart during their production (Ladefoged & Johnson, 2011), it can be observed that voiced sounds are relatively frequently devoiced, i.e. they are realized phonetically with little or no vocal fold vibration. According to Haghshenas (2012), the disappearance of the voicing feature in devoiced consonants does not cause it to be identical to its voiceless counterpart because there are other phonetic characteristics which make them distinct from each other. Ladefoged (2006) believes that the difference between voiced and voiceless sounds is often important in distinguishing them and we can find many pairs of words where this distinction is evident. As neutralization is defined as any phonological process that wipes out the contrast between two segments (Parker & Riley, 2005), the neutralization rules are thus the phonological rules which obliterate the contrast between two phonemes in certain environments (Fromkin, Rodman & Hyams, 2003). Roach (2009) believes that we use the term neutralization for cases where contrasts

[*]Master Student of Linguistics, Department of Foreign Languages, Faculty of Literature & Humanities, Shahid Bahonar University of Kerman, Iran.
[†]Assistant Professor, Department of Foreign Languages, Faculty of Literature & Humanities, Shahid Bahonar University of Kerman, Iran.

https://doi.org/10.30958/ajp.2-2-4 doi=10.30958/ajp.2-2-4

between phonemes, which exist in other places in the language, disappear in particular contexts.

Neutralization is one of the most important phonetic processes and has been studied in a number of languages such as English, French, Polish, Dutch, Catalan, German and etc, but unfortunately this issue has not been focused significantly in Persian, with the exception of Dr. Samareh (2007) who pointed it out from the articulatory phonetics point of view, not acoustically. This study investigated the perceptibility of neutralization in Persian according to the offset position in terms of acoustic features.

According to Wilson (2003), languages have numerous phonological processes which affect particular phonemes in particular contexts. Some of these processes categorically change one phoneme to another. Other phonological processes affect the articulation of a phoneme without changing it categorically into another phoneme. Often it is difficult to determine whether a putatively categorical rule is truly categorical, because although it seems as if one phoneme has changed into a different phoneme, careful phonetic analysis may reveal subtle cues to the original identity of the phoneme. If any remnants of the original phoneme can be detected, it would indicate that the change has not been categorical, but rather gradient in nature. It is thus important to be able to distinguish categorical changes from gradient ones, because the cognitive processes involved are probably quite different in both cases. His study investigates syllable final stop devoicing in Turkish with the aim of distinguishing between categorical and non-categorical processes.

Kleber, John and Harrington (2010) assert that the perceptibility of stop voicing in a domain-final neutralizing context in German according to various phonological models, is completely neutralized in favor of the voiceless category but according to various empirical studies, this is distinguishable phonetically.

Losad (2012) focuses on final devoicing in Friulian and on the connection between final devoicing and vowel lengthening. His aim is to account for both the phonetic phenomena involved in final devoicing and for the fact that stressed vowels are lengthened before devoiced obstruents but only in a word-final syllable.

Delforge (2011) has presented the first description of vowel devoicing in Quechua and argues that Quechua vowels sometimes devoice when followed by a voiceless consonant and the occurrence of this weakening process is determined by both phonetic and morphological factors.

Oostendorp (2008) believes that experimental evidence shows that syllable-final devoicing is often incomplete. This means that devoiced obstruents are phonetically subtly different from underlying voiceless ones and the speakers are sensitive to these differences.

Abdelli-Beruh (2012) has reported that based on the data analysis, voicing and devoicing assimilation of French /s/ and /z/ are similar in many regards: the absolute amounts of changes in voicing are equivalent in magnitude (0.77, 0.78) for the two processes and changes in voicing ratios are accompanied by changes in fricative and preceding vowel durations. So, these concomitant

alternations result in the increased acoustic-phonetic similarity between the assimilated and non-assimilated forms, suggesting that the two processes might be complete. However, data show that the voicing assimilation of /s/ is not rate dependent, which suggests that it might be obligatory, while the devoicing assimilation of /z/ is rate dependent, which suggests that it might be optional.

Rietveld and Benium (1987) believe that less attention has been paid to vowel quality. In their contribution, three experiments are reported concerning the relationship between vowel reduction and perceived stress. The results indicate that apart from factors like vowel type, subjective loudness and position in the word, the lack of spectral reduction is a cue for perceived stress when other parameters are considered.

In this research, we concentrate on voice/voiceless stop neutralization acoustically based on the Donca Steriade theory (1997) in domain-final position which is defined as offset position for the first time in the Persian language indicating that after the Persian long vowels [a:], [i:] and [u:]whether voiced stops [b], [d] ,[g] and voiceless stops [p], [t], [k]are neutralized in this position or not, and if this is so, whether it is complete or incomplete and under which effective phonetic features it occurs. Also, there is an attempt to make clear whether the fine phonetic details in neutralizing context are perceptible and moreover whether these subtle acoustic differences are conditioned by a series of factors or not. Consequently, to achieve the actual and desirable result, all the properties have been assumed.

Method

To achieve this goal, 18 one-syllable words have been chosen. Each word has the structure CVC. In every pair, only the phoneme for final C is changed in underlying voicing and the initial CV remains unchanged. Words were chosen in a way to include all Persian voiced and voiceless plosives: [p],[b],[t],[d], [k],[g] and all three Persian long vowels: [a:], [i:], [u:].Words were pronounced by 10 Persian native speakers, 5 males and 5 females aged between 22 and 42. The data were recorded in a quiet place by an A4TEcs microphone. Textgrids were made using PRATT (or Praat) software (Boersma, 2001).All the words were segmented and the border of vowels, consonants and the release of consonants were determined according to the waveform of the sounds in Osillogram and Spectogram and they were labeled using PRATT software, too. Acoustic analysis focused on different variables like: F0, F1, F2, F3, VOT and duration of vowels which are defined as the dependent variables. All of these are measured by SPSS software, ver.17.The independent variables of this study are offset and gender. In order to probe the relationship between the variables, the Post-hoc Bonferroni test is used. Each variable is investigated using descriptive and analytic statistics.

Table 1. *Data*

			Persian long vowels		
			[a:]	**[i:]**	**[u:]**
Plosives (stops)	voiced	**[b]**	[sa:b]	[si:b]	[su:b]
		[d]	[sa:d]	[si:d]	[su:d]
		[g]	[sa:g]	[si:g]	[su:g]
	voiceless	**[p]**	[sa:p]	[si:p]	[su:p]
		[t]	[sa:t]	[si:t]	[su:t]
		[k]	[sa:k]	[si:k]	[su:k]

Results

Duration

By comparing the results shown in table 2, it can be understood that the mean score of a vowel's duration in offset position in voice condition is more than that in a voiceless one. In addition, the mean of a long vowel's duration in voice condition in female mode is more than that in male mode and vice versa. The mean of a long vowel's duration in voiceless condition in male mode is more than that in female mode.

Table 2. M*ean Duration & Standard Deviation of Persian Long Vowels in Offset Position*

			mean	Std. deviation
Persian long vowels	voice	men	219.54	57.015
		women	230.61	37.011
	voiceless	men	214.25	53.193
		women	198.80	35.333

Table 3. *Analytic Statistics of Voicing and Gender in Duration of Persian Long Vowels in Offset Position*

	1.Tests of within-subjects effects		
	Mean square	f	Sig.
Voice	10089.086	10.146	.003
Gender	371.633	0.145	.706

Table 4. *Effect of Voicing on Duration of Persian Long Vowels in Offset Position*

Pairwise comparisons		Mean difference
Voice	Voiceless	16.741

Voice > 16.741 >Voiceless

Table 5. *Effect of Gender on Duration of Persian Long Vowels in Offset Position*

Pairwise comparisons		Mean difference
Men	Women	3.213

Men > 3.213 > Women

The effect of voicing on the duration of a preceding vowel is meaningful but the effect of gender on it is meaningless. The result of the Post-hoc Bonferroni test shows that in voice condition the duration of vowels is 16.741 ms more than the voiceless one, and also that in male mode it is 3.213 ms more than that in female mode, so the difference is significant.

F0

According to the results shown in table 6, it can be concluded that the mean F0 of long vowels in voice condition in offset position is less than that in a voiceless one. Also, it is found that the mean score of F0 in both voice and voiceless conditions in male mode is less than that in female mode in offset position.

Table 6. *Mean F0 and Standard Deviation of Persian Long Vowels in Offset Position*

			mean	Std. deviation
Persian long vowels	Voice	Men	137.69	13.769
		Women	221.28	25.814
	Voiceless	Men	139.77	14.628
		Women	228.39	31.580

Table 7. *Analytic Statistics of Voicing and Gender in F0 of Persian Long Vowels in Offset Position*

	1.Tests of within-subjects effects		
	Mean square	f	Sig.
Voice	1501.440	3.426	.068
Gender	526406.792	1082.459	1.0

Table 8. *Effect of Voicing on F0 of Persian Long Vowels in Offset Position*

Pairwise comparisons		Mean difference
Voice	Voiceless	-4.599

Voice < 4.599 < Voiceless

Table 9. *Effect of Gender on F0 of Persian Long Vowels in Offset Position*

Pairwise comparisons		Mean difference
Men	Women	-86.106

Men < 86.106 < Women

The effect of voicing on F0 of a preceding vowel is meaningless whereas the effect of gender on it is meaningful. The result of the Post-hoc Bonferroni test indicated that in voice condition, it is 4.599 ms less than the voiceless one and that in male mode it is 86.106 ms less than that in female mode.

F1

Vowel /a:/

Comparing F1 of vowel /a:/ in offset position in voice and voiceless conditions shows that the mean score of F1 in vowel /a:/ in voice condition is less than that in voiceless condition. In addition, the mean score of F1 of vowel /a:/ in voice and voiceless conditions in male mode is less than that in female mode.

Table 10. *Descriptive Analysis of Mean of F1 and Standard Deviation of Persian Long Vowel /a:/ in Offset Position*

			mean	Std. deviation
Persian long vowels	Voice	men	581.00	62.405
		women	753.00	38.807
	Voiceless	men	603.50	79.462
		women	746.67	47.828

Table 11. *Analytic Statistics of Voicing and Gender on F1 of Persian Long Vowel /a:/ in Offset Position*

	1.Tests of within-subjects effects		
	Mean square	f	Sig.
Voice	11497.195	11.521	.007
Gender	165773.876	36.777	.000

Table 12. *Effect of Gender on F1 of Persian Long Vowel /a:/ in Offset Position*

Pairwise comparisons		Mean difference
Voice	Voiceless	-32.330

Voice < 32.330 < Voiceless

Table 13. *Effect of Gender on F1 of Persian Long Vowel /a:/ in Offset Position*

Pairwise comparisons		Mean difference
Men	Women	-122.761

Men < 122.761 < Women

The effect of voicing and gender on F1 of preceding vowel /a:/ is meaningful and the result of the Post-hoc Bonferroni test indicates that in voice condition, it is 32.330 ms less than the voiceless one and that in male mode it is 122.761 ms less than that in female mode, so the difference is significant.

Vowel /i:/

Table14 shows that the mean of F1 of vowel /i:/ in voiceless condition is more than that in voice condition. Also it is found that the mean score of F1 in vowel /i:/ in male mode is less than in female mode in both voice and voiceless conditions.

Table 14. *Descriptive Analysis of Mean of F1 and Standard Deviation of Persian Long Vowel /i:/ in Offset Position*

			mean	Std. deviation
Persian long vowels	Voice	men	281.67	22.669
		women	355.25	38.629
	Voiceless	men	321.83	81.147
		women	406.50	73.889

Table 15. *Analytic Statistics of Voicing and Gender in F1 of Persian Long Vowel /i:/ in Offset Position*

	1.Tests of within-subjects effects		
	Mean square	f	Sig.
Voice	245.818	.071	.795
Gender	37469.455	6.912	.025

Table 16. *Effect of Voicing on F1 of Persian Long Vowel /i:/ in Offset Position*

Pairwise comparisons		Mean difference
Voice	Voiceless	-4.727

Voice < 4.727 < Voiceless

Table 17. *Effect of Gender on F1 of Persian Long Vowel /i:/ in Offset Position*

Pairwise comparisons		Mean difference
Men	Women	-58.364

Men < 58.364 < Women

The effect of voicing on F1 of preceding vowel /i:/ is meaningless but the effect of gender on it is meaningful. The result of the Post-hoc Bonferroni test indicates that in voice condition, it is 4.727 ms less than the voiceless one and that in male mode it is 58.364 ms less than that in female mode.

Vowel /u:/

Comparing the mean F1 of vowel /u:/ in voice and voiceless conditions shows that the mean score of vowel /u:/ in voice condition is less than that in voiceless condition and in both conditions the mean score of vowel /u:/ in male mode is less than that in female mode.

Table 18. *Descriptive Analysis of Mean of F1 and Standard Deviation of Persian Long Vowel /u:/ in Offset Position*

			mean	Std. deviation
Persian long vowels	Voice	men	374.17	74.959
		women	439.00	59.597
	Voiceless	men	410.75	102.008
		women	442.67	82.487

Table 19. *Analytic Statistics of Voicing and Gender in F1 of Persian Long Vowel /u:/ in Offset Position*

	1.Tests of within-subjects effects		
	Mean square	f	Sig.
Voice	4860.188	1.141	.308
Gender	28081.687	2.624	.134

Table 20. *Effect of Gender on F1 of Persian Long Vowel /u:/ in Offset Position*

Pairwise comparisons		Mean difference
Voice	Voiceless	-20.125

Voice < 20.125 < Voiceless

Table 21. *Effect of Gender on F1 of Persian Long Vowel /u:/ in Offset Position*

Pairwise comparisons		Mean difference
Men	Women	-48.375

Men < 48.375 < Women

The effect of voicing and gender on F1 of preceding vowel /u:/ is meaningless and the result of the Post-hoc Bonferroni test indicates that in voice condition, it is 20.125 ms less than the voiceless one and that in male mode it is 48.375 ms less than that in female mode.

F2

Vowel /a:/

According to the results shown in table 22, it can be concluded that the mean score of F2 of vowel /a:/ in voice condition is more than that in the voiceless one. The findings indicate that the mean score of F2 of vowel /a:/ in voice condition and male mode is the same as that in voiceless condition and less than female mode.

Table 22. *Descriptive Analysis of Mean of F2 and Standard Deviation of Persian Long Vowel /a:/ in Offset Position*

			mean	Std. deviation
Persian long vowels	Voice	men	1310.42	297.218
		women	1350.50	112.050
	Voiceless	men	1274.08	289.541
		women	1350.67	130.910

Table 23. *Analytic Statistics of Voicing and Gender in F2 of Persian long Vowel /a:/ in Offset Position*

	1.Tests of within-subjects effects		
	Mean square	f	Sig.
Voice	3348.900	.167	.693
Gender	83174.400	.796	.396

Table 24. *Effect of Gender on F2 of Persian Long Vowel /a:/ in Offset Position*

Pairwise comparisons		Mean difference
Voice	Voiceless	18.300

Voice >18.300> Voiceless

Table 25. *Effect of Gender on F2 of Persian Long Vowel /a:/ in Offset Position*

Pairwise comparisons		Mean difference
Men	Women	-91.200

Men < 91.200 < Women

The effect of voicing and gender on F2 of preceding vowel /a:/ is meaningless and the result of the Post-hoc Bonferroni test indicates that in voice condition, it is 18.300ms more than the voiceless one and that in male mode it is 91.200ms less than that in female mode.

Vowel /i:/

The results which are presented in table 26 show that the mean score of vowel /i:/in voiceless condition is more than that in voice condition. In addition, the mean of F2 of vowel /i:/ in male mode is less than that in female mode in both voice and voiceless conditions.

Table 26. *Descriptive Analysis of Mean of F2 and Standard Deviation of Persian Long Vowel /i:/ in Offset Position*

			mean	Std. deviation
Persian long vowels	voice	men	2277.42	96.507
		women	2547.75	152.205
	voiceless	men	2274.58	98.521
		women	2562.25	139.044

Table 27. *Analytic Statistics of Voicing and Gender in F2 of Persian Long Vowel /i:/ in Offset Position*

	1.Tests of within-subjects effects		
	Mean square	f	Sig.
Voice	408.333	.075	.789
Gender	934092.000	41.200	1.0

Table 28. *Effect of Voicing on F2 of Persian Long Vowel /i:/ in Offset Position*

Pairwise comparisons		Mean difference
Voice	Voiceless	-5.833

Voice < 5.833< Voiceless

Table 29. *Effect of Gender on F2 of Persian Long Vowel /i:/ in Offset Position*

Pairwise comparisons		Mean difference
Men	Women	-279.000

Men < 279.000< Women

The effect of voicing on F1 of preceding vowel /u:/ is meaningless but the effect of gender on it is meaningful. The result of the Post-hoc Bonferroni test indicates that in voice condition it is 20.125 ms less than the voiceless one and that in male mode it is 48.375 ms less than that in female mode.

Vowel /u:/

Based on the results shown in table 30, it can be concluded that the mean of F2 of vowel /u:/ is more in a voice condition than in a voiceless one . Also the mean of F2 of vowel /u:/ in male mode in both voice and voiceless conditions is more than that in female mode.

Table 30. *Descriptive Analysis of Mean of F2 and Standard Deviation of Persian Long Vowel /u:/ in Offset Position*

			mean	Std. deviation
Persian long vowels	voice	men	1509.75	481.707
		women	1171.00	261.150
	voiceless	men	1508.00	451.567
		women	1158.92	172.060

Table 31. *Analytic Statistics of Voicing and Gender in F2 of Persian Long Vowel /u:/ in Offset Position*

	1.Tests of within-subjects effects		
	Mean square	f	Sig.
Voice	574.083	.013	.911
Gender	1419344.083	8.777	.013

Table 32. *Effect of Voicing on F2 of Persian Long Vowel /u:/ in Offset Position*

Pairwise comparisons		Mean difference
Voice	Voiceless	6.917

Voice > 6.917 > Voiceless

Table 33. *Effect of Gender on F2 of Persian Long Vowel /u:/ in Offset Position*

Pairwise comparisons		Mean difference
Men	Women	343.917

Men > 343.917 > Women

The effect of voicing on F2 of preceding vowel /u:/ is meaningless but the effect of gender on it is meaningful. The result of the Post-hoc Bonferroni test indicates that in voice condition, it is 20.125 ms less than the voiceless one and that in male mode it is 48.375 ms less than that in female one.

F3

The results show that the voicing and gender do not have influence on the F3 of Persian long vowels in offset position. So, the effect of them on it is meaningless.

COG

Comparing the results of this study indicates that the effect of voicing and gender on the COG of the preceding vowel is not significant and it is meaningless.

Conclusion

According to the results of this study, it can be concluded that the voicing of the stop in offset position influences the duration of its preceding vowel. It means that the vowel before the voiced stop becomes longer than the vowel which is followed by the voiceless stop. The F0, F1 (excluding vowel /a:/), F2 of the long vowels are not affected so much by the voicing of the following stop and the difference is meaningless. In addition, it is found that the gender variable affects the duration of the vowels; it is longer before the voiced stops in female mode than in male mode. Also the gender variable influences the F0, F1 (excluding vowel /u:/), F2 (excluding vowel /a:/) of the long vowels in offset position such that in male mode it is more than that in female mode so the effect of gender on these elements is meaningful. In addition, in domain-

final position (offset) of mono-syllabic words which have CVC structure in Persian, the measuring of VOT which is defined as the interval between the release of a closure and the start of the voicing is impossible because in this position in the Persian language the word doesn't have VOT. Also the effect of voicing and gender on the mean of F3 and COG of the preceding vowel is meaningless.

Finally, by comparing the results, the total consequence is that after the Persian long vowels **/a:/, /i:/** and **/u:/,** the difference between the voiced and voiceless consonants is not neutralized. So, these findings show the absence of complete neutralization of underlying voice in offset position in the Persian language.

References

Abdelli-Beruh, N., 2012. Voicing and devoicing of French /s/ and /z/. *J Psycholinguist Res,* 41(5), pp.371-386.

Boersma, P., 2001. Praat, a system for doing phonetics by computer. *Glot International*, 5(9/10), pp.341-345.

Delforge, A.M., 2011. *Vowel devoicing in Cusco Collao Quechua*. Hong Kong.

Fromkin, V., Rodman, R., & Hyams, N., 2003. *An Introduction to Language.*7th ed. Heinle: USA.

Haghshenas, A.M., 2012. *Avashenasi*. 13th ed. Nashragah: Iran.

Kleber, F., John, T., & Harrington, J., 2010. The implication for speech perception of incomplete neutralization of final devoicing in German. *Journal of Phonetics*, 38, pp.185-196.

Ladefoged, P., 2006. *A Course in Phonetics.* 5th ed. Wadsworth: USA.

Ladefoged, P., & Johnson, K., 2011. *A Course in Phonetics.* 6th ed. Wadsworth: USA.

Losad, P., 2012. Final devoicing and Vowel lengthening in Friulian: A representational approach. *Lingua*, 122, pp.922-951.

Oostendorp, M., 2008. Incomplete devoicing in formal phonology. *Lingua,* 118, pp.1362-1374.

Parker, F., & Riley, K., 2005. *Linguistic for Non-Linguists.* 4th ed. Pearson: USA.

Rietveld, A.C.M., & Koopmans-van Beinum, F.J., 1987. Vowel reduction and stress. *Speech Communication*, 6, pp.217-229.

Roach, P., 2009. *English Phonetics and Phonology*. 4th ed. Cambridge university press: UK.

Samareh, Y., 2007. *Ava ShenasiZabaneFarsi: AvahavaSakhteAvayiHeja*. 7th ed. Nashredaneshgahi: Tehran.

Steriade, D., 1997. *Phonetics in Phonology: The Case of Laryngeal Neutralization.* Ms., UCLA.

Wilson, S., 2003. A phonetic study of voiced, voiceless and alternating stops in Turkish. *CRL Newsletter*, 15(1).