Analyzing the COG and intensity of Kermani vowels in the process of vowel reduction

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The purpose of this article is the study of vowel reduction in Kermani accent. In this study, five men and five women who were native speakers of Kermani accent, were asked to pronounce 24 words and repeat them for 3 times. The vowels of 12 words were in stressed syllables and the vowels of the other words were in unstressed syllables. The participants' production was recorded using Shure microphone and analyzed by PRAAT software (Ver. 5.2.24). Results show that COG and intensity of vowels decreased in unstressed syllables and that the vowel reduction in Kermani accent is centripetal.

Keywords: *COG, intensity, vowel reduction*

1. Introduction

1.1 *Vowel reduction*

Chomsky & Halle (1968) define vowel reduction as a gradual shift of a [-stressed] vowel toward schwa. Crosswhite (2000) considered two distinct types of vowel reduction: sonority-driven reduction and perception-based (contrast-enhancing) reduction. Although both classification of reduction cause vowel neutralization in unstressed syllables, they do differ in some characteristics. He illustrated that sonority-driven reduction targets vowels with respect to their sonority class. It means that during the sonority-driven reduction, more sonorous vowels are reduced in unstressed syllables and shift toward less sonorous ones. According to sonority-driven constraints, weak positions will prefer less sonorous vowels to more sonorous ones. Perception-based reduction, unlike sonority-driven reduction, can target any natural class of vowels. In other words, in this process the sonority of vowel is not the matter. In fact, the important point is the tendency of weak vowels to move towards the corners of the vocalic diagram. Harris (2005) also distinguished vowel reductions in two categories: centripetal and centrifugal. In centrifugal reduction, like contrast-enhancing reduction, vowels shift toward the peripheral vowels. Mid vowels can be seen just in stressed syllables and if they are in unstressed syllables, they tend to move toward the peripheral vowels [ɒ, i, u], of the vocalic diagram. In centripetal reduction, vowels of unstressed syllables shift toward the centre and near to the quality of vowel /ə/. Some vowels tend to move toward the central vowels and some others to the peripheral ones. Centripetal reduction is not the same as sonority-driven reduction. In centripetal reduction, sonority may not be reduced. Sheikh & Bijankhan (2010) investigated that the reason of vowel reduction of [æ] in the Persian language, was assimilation not centralization. Because F1, F2, F3 and COG of this vowel indicated that it was close to [ɒ]. Thus, in the context at hand, a vowel like [ɒ] is reduced and as a result, vowel reduction is not sonority-driven. In the Persian, the vowel reduction occurs from less sonorous vowels toward more sonorous ones. They also indicated that the process of vowel reduction in the Persian language was not contrast-enhancing too. This language, because of many changes and varieties of unstable vowels, had a syncretistic approach.

1.2 *Centre of gravity*

The centre of gravity is in a sense the mean spectral frequency over some time span. The measure is particularly useful for segments without well-defined formant structure, like those with voiceless friction (van Son & Pols 1999). The centre of gravity of a spectrum is in a sense, the "mean" frequency. For sonorants, the centre of gravity is related to the spectral slope, the sleeper the slope, the lower the centre of gravity (van Son & Pols 1995).

1.3 *Intensity*

Lehiste (1970) defined sound intensity as the square of the pressure variations of the sound wave. Therefore, the decibel equivalent of a particular pressure ratio is 20 times the logarithm to the base 10 of that ratio. At the lowest frequencies, a much greater intensity is required for a sound to be audible than at higher frequencies. Intensity is a physical characteristic of sound. Loudness is the subjective property of a sound that is most directly related to intensity. Sluijter et al. (1997) and Fant & Kruckenberg (1994) found that intensity is not a reliable cue to distinguish stressed and unstressed syllables and there is no clear relationship between these two concepts.

2. Statement of the problem

The acoustic quality of vowels changes during the process of vowel reduction. In this study we are going to analyze the change of vowels' COG and intensity in stressed and unstressed syllable in Kermani accent and discuss the process of vowel reduction in the vowels at hand. According to Bollinger (1989), whereas full vowels are distinguished by their quality such as height, backness and roundness, reduced vowels can't be recognized by these characteristics. Van Bergem (1995) believes that vowel reduction happens whenever a vowel has a gradual shift toward schwa. Van Bergem (1993) and Moon & Lindblom (1994) found that reduced vowels have shorter duration and more centralized formants than non-reduced ones.

3. Methodology

In this study, ten research participants (five men and five women with Kermani accent), were asked to pronounce 24 words and repeat them for 3 times. The vowels of 12 words were in stressed syllables and the vowels of the other words were in unstressed syllables.

Table 1 *Data of the study*

Vowels	Kermani pronunciation	Standard pronunciation	Meaning	Kermani pronunciation	Standard pronunciation	Meaning
[æ]	['sær]	['sær]	'head'	[sə'rɒ]	[sær'ɒ]	'heads'
	['sæg]	['sæg]	'dog'	[sə'gɒ]	[sæg'ɒ]	'dogs'
[e]	['ser]	['ser]	'secret'	[sə'rɒ]	[se'rɒ]	'secrets'
	['del]	['del]	'heart'	[də'lɒ]	[de'lɒ]	'hearts'
[o]	['kod]	['kod]	'code'	[ko'dɒ]	[ko'dɒ]	'codes'
	['boz]	['boz]	'goat'	[bo'zɒ]	[bo'zɒ]	'goats'
[ɒ]	['kɒr]	['kɒr]	'activity'	[kɒ'rɒ]	[kɒ'rɒ]	'activities'
	['ʃɒm]	['ʃɒm]	'dinner'	[ʃɒ'mi]	[ʃɒ'mi]	'a kind of food'
[i]	['ʃir]	['ʃir]	'milk'	[ʃi'ri]	[ʃi'ri]	'milky'
	['sir]	['sir]	'garlic'	[si'ri]	[si'ri]	'fullness'
[u]	['suz]	['suz]	'cold wind'	[su'zɒn]	[su'zɒn]	'sweltering'
	['ruz]	['ruz]	'day'	[ru'ze]	[ru'ze]	'fast'

In case of incorrect reading of the words, they were allowed to repeat themselves. The participants' production was recorded using Shure microphone and analyzed by PRAAT (5.3.06) software. Using PRAAT, all the words were segmented so that the boundaries of vowels were determined. In making a textgrid, using sound wave and spectrogram, simultaneously, increases the accuracy in measuring the data. Then, the amount of COG and intensity was measured in stressed and unstressed syllables. In order to compare the behaviour of vowels at hand, in stressed and unstressed syllables, SPSS 16 and repeated measure ANOVA were used.

4. Variables

4.1 *Dependent Variables*

This kind of variables is quantitative and measured to determine the effect of the independent variables. The dependent variables of this study are:

Intensity: Intensity or energy of a wave sound is determined by its amplitude. The more the amplitude of a signal, the more the intensity of the sound is. The unit of sound intensity is decibel (dB) (Burzio 2007).

Centre of gravity (COG): The centre of gravity is the mean spectral frequency over some time span. This measure is used for segments without well-defined formant structures (van Son & Pols 1999).

4.2 *Independent Variables*

These qualitative kinds of variables are those over which the researcher has no control. In this research independent variables are:

Stressed syllable: Stressed syllables are articulated with more articulatory effort in the respiratory system and increase of vocal folds tension. It makes sounds of higher pitch (Ladefoged 2001). A syllable is stressed whenever there is some change in its fundamental frequency, amplitude and duration. The most effective factors for a stressed syllable are fundamental frequency, amplitude and duration respectively (Lieberman 1960).

Unstressed syllable: Unstressed syllables, in comparison with stressed syllables, are articulated with less articulatory effort. Vowels of unstressed syllables are similar to central vowels. In stressed syllables, the duration of vowels and consonants is more than that in unstressed syllables (Lehiste 1997).

5. Data analysis

This section is based on the pronunciation of ten research participants. To determine the relationship between the variables, the post-hoc Bonferroni test is used.

5.1 *Descriptive Statistics*

5.1.1 *Centre of gravity*

According to Table 2, it can be understood that the mean score of centre of gravity, for all the vowels in stressed syllables, is more than that in unstressed syllables (Figure 1).

Table 2 *Standard deviation, mean and range of COG of vowels in Kermani accent*

	Mean	**Standard deviation**	**95% Confidence Interval**		
			Range	**Lower Bound**	**Upper Bound**
Stressed Syllable	3728.46	803.391	4287	1905	6192
Unstressed Syllable	3165.6	843.952	3653	1385	5038

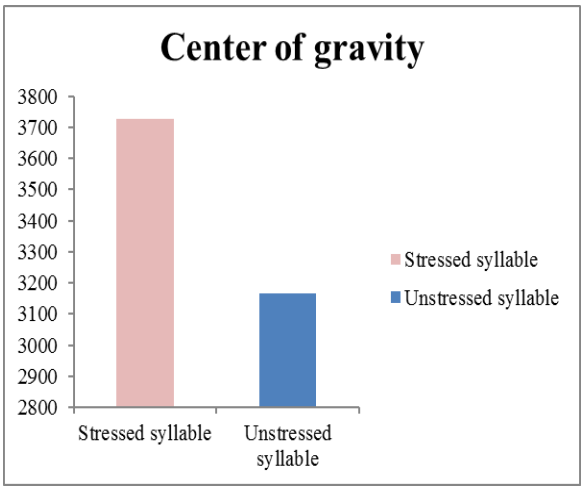

Figure 1 *Mean COG of vowels in Kermani accent*

5.1.2 *Intensity*

Comparing intensity of vowels in stressed and unstressed syllables, we found that mean score of intensity in stressed syllables is more than that in unstressed syllables (Table 3 and Figure 2).

Table 3 *Standard deviation, mean and range of intensity of vowels in Kermani accent*

	Mean	**Standard deviation**	**95% Confidence Interval**		
			Range	**Lower Bound**	**Upper Bound**
Stressed Syllable	68.62	5.371	23	60	83
Unstressed Syllable	64.24	4.549	25	53	78

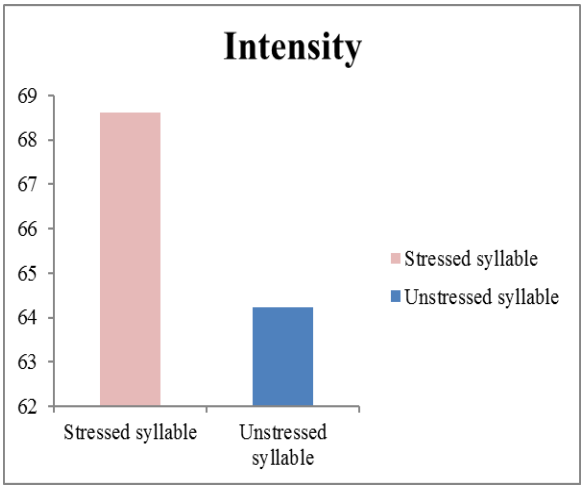

Figure 2 *Mean intensity of vowels in Kermani accent*

5.2 *Analytical Statistics*

In this part, the repeated measure ANOVA was applied for analyzing the data and its significance level was α: 0.05. So, the confidence interval would be 95%. If the value-p of the repeated measure ANOVA was less than 0.05, the post-hoc Bonferroni test was used to analyze COG and intensity of vowels.

5.2.1 *Centre of gravity*

According to Table 4 and unlike stressed syllables, centre of gravity of all the [æ, e, o, ɒ, u, i] vowels decreases in unstressed syllables. Also the result of the repeated measure ANOVA confirms that the effect of stress on the COG is significant (P: 0.000). The post-hoc Bonferroni test shows that mean score of vowels' COG in stressed syllables is 562.852 Hz more than that in unstressed syllables (Figure 3).

Table 4: Analytic statistics of stress in COG of vowels

Stress	Type III Sum of Squares	df	Mean Square	F	Sig.
	23601806.12	1	23601806.12	80.399	0.000

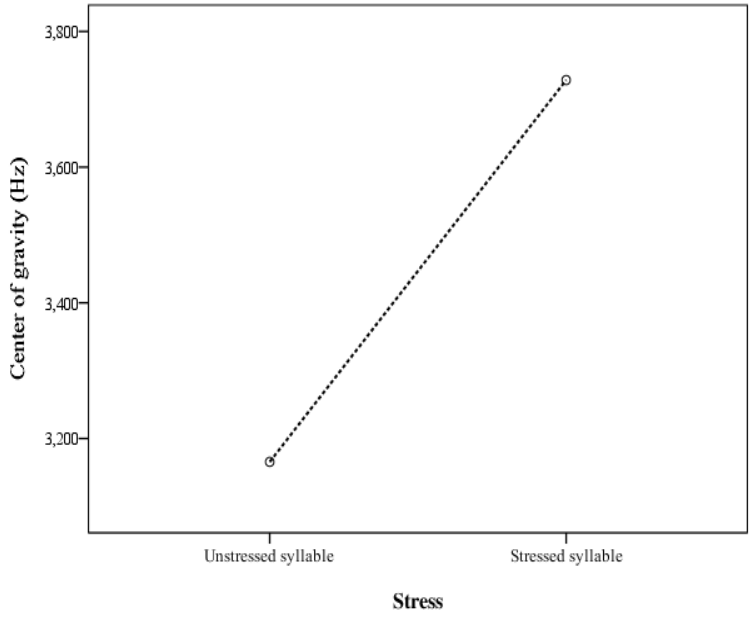

Figure 3 *Mean COG of vowels in stressed and unstressed syllables*

5.2.2 *Intensity*

Table 5 indicates the effect of stress on the Kermani vowels' intensity. It is obvious that intensity of vowels in unstressed syllables is less than that in stressed ones. The repeated measure ANOVA shows that the effect of stress on the vowel's intensity is significant (P: 0.000). According to the post-hoc Bonferroni test, the intensity of vowels in stressed syllables is 4.376 dB more than that in unstressed syllables (Figure 4).

Table 5 *Analytic statistics of stress in intensity of vowels*

Stress	Type III Sum of Squares	df	Mean Square	F	Sig.
	1684.813	1	1684.813	250.543	0.000

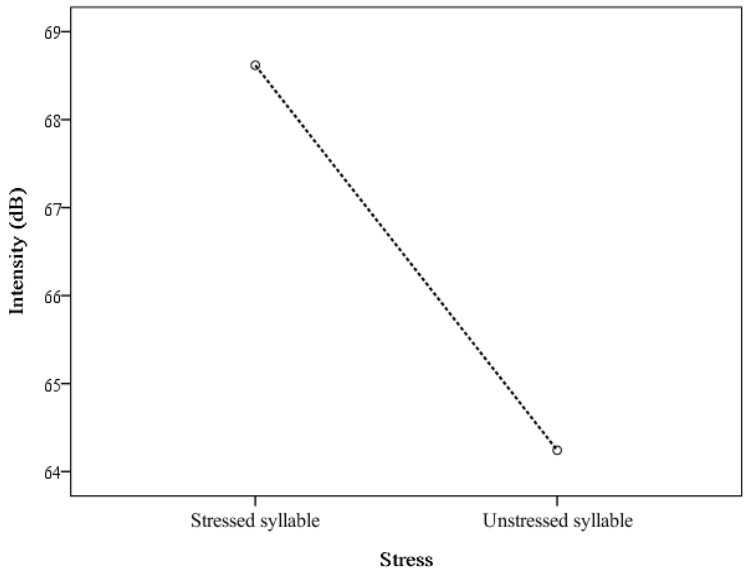

Figure 4 *Mean intensity of vowels in stressed and unstressed syllables*

6. Conclusion

According to the results of this study, in Kermani accent the COG of vowels decreases in unstressed syllable. Sluijter (1995) and van Son & Pols (1995) supported these results in Dutch and English. They illustrated that as the de-accentuation of vowels strongly correlates with vowel reduction, it is predictable that reduction will cause a lower centre of gravity. In another experiment by van Son et al. (2004), they compared the process of vowel reduction in Dutch, Finnish and Russian. They concluded that in these languages, four variables of duration, formant space, spectral centre of gravity and intensity decreased in unstressed syllables and the link between vowel reduction and redundancy might be a language universal. In addition to COG, the intensity of vowels decreases in unstressed syllables. Burzio (2007) investigated that in English, the intensity of vowels decreased in unstressed syllables. Additionally, some of the vowels' distinctions were neutralized and shifted toward [ə] in unstressed syllables. Morton & Jassem (1965) and Fry (1955) studied the effect of duration and intensity on the stressed and unstressed syllables. They used synthetic nonsense syllables of the form /sisi/, /sɔsɔ/ and /sasa/ in English. Generally, they concluded that the more intense and longer syllables were more likely to be marked as stressed and in the unstressed syllable the intensity of vowels decreases. Rigault (1962) also did the same experiment in French. Again the results of his experiment showed that the relative importance of duration and intensity seemed to be approximately the same.

References

Bollinger, Dwight. 1989. *Intonation and its uses: Melody in Grammar and Discourse.* Stanford University Press.

Burzio, Luigi. 2007. Phonology and Phonetics of English Stress and Vowel Reduction. *Language Science*. 154-176.

Chomsky, Noam & Halle, Morris. 1968. *The Sound Pattern of English*. New York: Harper and Row.

Crosswhite, Katherine M. 2000. Sonority-Driven reduction. *Proceedings of the Twentysixth Annual Meeting of the Berkeley Linguistics Society: General Session and Parasession on Aspect*. 77-88.

Fant, Gunnar & Kruckenberg, Anita. 1994. Notes on stress and word accent in Swedish. In *Proceedings of the International Symposium on Prosody, Yokohama*. 2-3.

Fry, Dennis B. 1955. Duration and intensity as physical correlates of linguistic stress. *Journal of the Acoustic Society of America* 27. 765-768.

Harris, John. 2005. Vowel reduction as information loss. *Headhood, elements, specification and contrastivity*. Amsterdam: Benjamins. 119-132.

Ladefoged, Peter. 2001. *Vowels and Consonants: An Introduction to the Sounds of Languages*. Oxford: Blackwell.

Lehiste, Ilse. 1997. Search for phonetic correlates in Estonian prosody. In *Estonian Prosody: Papers from a Symposium.* 11-35.

Lieberman, Philip. 1960. Some acoustic correlates of word stress in American English. *The Journal of the Acoustical Society of America* 32(4). 451-454.

Moon, Seung J. & Lindblom, Bjorn. 1994. Interaction between duration, context, and speaking style in English stressed vowels. *The Journal of the Acoustical society of America* 96(1). 40–55.

Morton, John & Jassem, Wiktor. 1965. Acoustic correlates of stress. *Language and Speech* 8(3). 159-181.

Rigault, Andre. 1962. Rôle de la fréquence, de l'intensitéet de la duréevocaliquesdans la perception de l'accent en francais. In *Proceedings of the Fourth International Congress of Phonetic Sciences*, 48. Helsinki.

Sheikh Sangtajan, Shahin & Bijankhan, Mahmood. 2010. Barrasiy-e kahesh-e vakeyidarzaban-e Farsiy-e mohavereyi. *Majaley-e Pajuheshhay-e zabanshenasi*. 35-48.

Sluijter, Agaath M. 1995. Intensity and vocal effort as cues in the perception of stress. *Proceedings of Eurospeech*, 1995, vol. 95. 941-944.

Sluijter, Agaath M. & van Heuven, Vincent J. 1996. Spectral balance as an acoustic correlate of linguistic stress. *The Journal of the Acoustical society of America* 100(4). 2471-2485.

Sluijter, Agaath. M. & van Heuven, Vincent J. & Pacilly, Jos. J. 1997. Spectral balance as a cue in the perception of linguistic stress. *The Journal of the Acoustical Society of America* 101(1). 503-513.

van Bergem, Dick R. 1993. Acoustic vowel reduction as a function of sentence accent, word stress, and word class. Speech *communication* 12. 1-23.

van Bergem, Dick R. 1995. Perceptual and acoustic aspects of lexical vowel reduction, a sound change in progress. *Speech Communication* 16(4). 329-358.

van Son, Rob & Pols C. W. 1995. Acoustic consonant reduction: A comparison. *Institute of Phonetic Sciences, University of Amsterdam, Proceedings* 19. 83-91.

van Son, Rob. & Pols C. W. 1999. An acoustic description of consonant reduction. *Speech communication* 28 (2). 125-140.

van Son, R. & Bolotova, Olga & Pols, Louis C. & Lennes, Mietta. 2004. Frequency effects on vowel reduction in three typologically different languages (Dutch, Finish, Russian). *INTERSPEECH*.

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In SKASE Journal of Theoretical Linguistics [online]. 2015, vol. 12, no.2 [cit. 2014-06-25]. Available on web page http://www.skase.sk/Volumes/JTL28/pdf_doc/02.pdf ISSN 1336- 782X.