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Speech rhythm variation in dialects of Spanish: Applying the Pairwise Variability Index and Variation Coefficients to Peruvian Spanish

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Abstract

Spanish rhythm has been traditionally classified as syllable-timed. Recent rhythm metrics have been employed to reconsider this typology in terms of differences in vocalic and consonantal variation. Several cross-dialectal studies have begun to uncover differences in rhythm within a given language. Yet research on differences in Spanish rhythm has not been conducted. In this paper, Peruvian Spanish is examined in order to observe possible differences in Spanish rhythm according to origin (Lima vs. Cuzco) and according to language background (native Spanish speaker vs. native Spanish-Quechua bilingual). Results show that Peruvian Spanish in general has greater vocalic variation and less consonantal variation that previously reported. Differences between Lima and Cuzco Spanish are observed, although both groups of Cuzco speakers appear to be using similar speech rhythms. This research points to the need for further cross-dialectal research on rhythm in Spanish.

1. Introduction

In the rhythm class typology put forth by Pike [1] and Abercrombie [2], Spanish has been described as a syllable-timed language, such that spacing between syllables is relatively even. This characterization is made in comparison to languages described as stress-timed, such as English or German, which are considered to have relatively even spacing between stresses, and to mora-timed languages, such as Japanese, that have even spacing between mora [3]. Even though subsequent research has demonstrated the lack of consistency in the presence of these isochronous syllables, stresses or morae (see [4] and [5] for discussion), the division of languages into different types of rhythm classes continues to be examined.

Recent research by Ramus, Nespor and Mehler [6] has examined the alternation between vowels and consonants, and has shown that variation of each within an utterance corresponds with the traditional rhythm class description. While stress-timed languages show greater consonantal variation (ΔC) than syllable-timed languages, a higher percentage of the overall utterance was vocalic (%V) in syllable-timed languages. In order to account for local differences in speaking rate, a pairwise variability index ("PVI") has been used to calculate changes in duration between pairs of neighboring vowels and between pairs of neighboring consonants in a given utterance [5, 7]. Pairwise calculations of differences in duration of neighboring syllables, 'pseudo'-syllables, and feet have also been made in relation to rhythm classes [8] [9].

Further examination of speaking rate has shown that greater effects are found in consonantal variation as it relates to rhythm, while the overall percentage of vocalic sequences in an utterance remains more robust [10], [11]; in order to better account for speaking rate, a variation coefficient for consonants, or "VarcoΔC" has been employed. In a similar vein, White and Mattys [12-14] found normalization of vocalic sequences, or "VarcoV," along with V% to best describe rhythm classes in both speaking and perception tasks. Last, the distinction among rhythm classes has been suggested to be even more basic, as a difference between voiced and voiceless segments [15].

As new research methods for analyzing speech rhythm have been developed, cross-dialectal variation in speech rhythm has been observed. In particular, differences have been found between Singapore and British English [16], Taiwan and American English [17], Welsh Valleys and Orkney Islands English compared to standard southern British English [13], Eastern and Western Arabic varieties [18], Bari, Naples and Pisa varieties of Italian [9], and European Portuguese compared with Brazilian Portuguese [19]. However, what differences in rhythm may exist across Peninsular and Latin American varieties of Spanish has yet to be determined. The Ramus et al [6] study showed Spanish to be similar to other typically syllable-timed languages such as French, Italian and Catalan in terms of consonantal variation and overall vocalic interval. Yet, as Ramus [20] notes, larger scale studies are needed with more speakers in order to determine if previous observations are study and corpus-dependent or actually representative of distinct language rhythms.

Of the Spanish varieties found, those in contact with other languages may be likely candidates to show prosodic differences, including differences in intonation and rhythm. Acquisition research has found Mexican-Spanish/American-English bilingual children to begin with less distinct rhythm patterns for each language, but then to develop more target-like rhythm patterns with age [21]. Influence of native language on stress-timed and syllable-timed rhythm can also be observed in the comparison of utterances produced by English and Spanish L1 and L2 speakers [12]. Since indigenous languages have often been described in the literature as affecting the development of Latin American varieties of Spanish [22-24], Peruvian Spanish in contact with Quechua may be taken as a case study in order to examine potential differences in speech rhythm. Specifically, Andean Spanish as spoken in Cuzco has developed through a greater degree of contact with Quechua in comparison to Lima Spanish, where the increase in the percentage of Quechua speakers is a relatively more recent phenomenon.

In this paper, data from the analysis of Peruvian Spanish rhythm will be presented with the use of several of the previous methods described. In doing so, Peruvian speakers will be compared across groups and with Spanish data reported in the literature. Likewise, results from the different rhythm metrics will be discussed.

2. Experiment

2.1. Speech materials

The data are a set of declaratives collected as part of a study of Peruvian Spanish intonation in contact with Quechua [25]. The utterances were all short declaratives with SOV word order ranging from 9-13 syllables in length. Twelve different target sentences were read in a pseudo-randomized order twice, giving twenty-four productions per speaker.

2.2. Speakers

Three native speakers of Lima Spanish (LIM_NSS) have been compared to two different groups of Cuzco Spanish speakers. The first group consists of three native Spanish speakers (CUZ_NSS) and the second group includes three native Quechua-Spanish bilinguals (CUZ_NQSS), i.e., speakers who learned both Quechua and Spanish in early childhood before entering the school system. All participants in this study were male speakers between the ages of 18-39 and had completed or were enrolled in post-secondary education. Speakers were recorded in Lima and Cuzco and were living in their region of origin at the time of the study.

2.3. Rhythm metrics

The following measurements of each utterance have been made. First, employing the Ramus et al [6] metrics, the utterances were divided into consonantal and vocalic sequences, such that adjacent vowels were considered to be part of the same sequence, even if they belonged to different syllables; likewise ambisyllabic adjacent consonants were considered to be part of the same sequence. This procedure was employed based on Ramus et al's observation that in infant speech perception the alternation between consonantal and vocalic sequences are cues that infants use to distinguish between language rhythms. From the segmentation of the utterance into sequences of vowels and consonants, the percentage of vocalic intervals (V%) was determined as the total duration of all vocalic sequences divided by the total duration of the utterance. In addition, the standard deviation of individual vocalic sequence durations was calculated (ΔV), as well as the standard deviation of consonantal sequence duration (ΔC).

The Pairwise Variability Index [5, 7] was then calculated by measuring the difference in duration of two subsequent sequences, as in (1) below used for consonants (raw PVI-C). A normalization procedure was employed for vowels to adjust for local differences in speaking rate by dividing by the mean duration for the two neighboring sequences, as in (2) (to give the nPVI-V).

$$\text{(1) rPVI-C}= \left[\sum_{K=1}^{m-1} \left| d_k - d_{k+1} \right| /(m-1)\right]$$

$$\text{(2) nPVI-V}= 100\times\left[\sum_{K=1}^{m-1} \left| \frac{d_k - d_{k+1}}{(d_k + d_{k+1})/2} \right| /(m-1)\right]$$

A third type of calculation has also been conducted to account for changes in tempo in a given utterance. The standard deviation of an interval is divided by the mean value of those intervals and multiplied by 100 to give a variation coefficient, either VarcoΔC for consonants [10, 11] or VarcoΔV for vowels [12-14].

3. Results

The findings for the three groups and for individual speakers are listed in the tables below. The results from the analysis of %V, ΔC, and ΔV are reported in [26]; the results from the calculation of PVI and Varco metrics appear in Tables 1 and 2. A summary table of the results for the three groups is included in Table 3.

Table 1: *Results for PVI analysis*

Speaker	nPVI-V	(SE)	rPVI-C	(SE)
L_NSS	**39**	**(1.6)**	**37**	**(1.4)**
L01_NSS	36	(2.6)	35	(2.0)
L02_NSS	41	(2.6)	36	(2.3)
L03_NSS	40	(3.1)	43	(3.0)
C_NSS	**33**	**(1.2)**	**45**	**(2.0)**
C01_NSS	27	(1.3)	37	(2.5)
C02_NSS	34	(2.2)	45	(2.3)
C03_NSS	36	(2.1)	52	(4.3)
C_NQSS	**31**	**(1.3)**	**43**	**(1.6)**
C21_NQSS	32	(1.9)	39	(2.6)
C22_NQSS	33	(2.5)	46	(2.6)
C23_NQSS	29	(2.1)	44	(2.8)

Table 2: *Results for Varco calculation*

Speaker	VarcoΔV	(SE)	VarcoΔC	(SE)
L_NSS	**36**	**(2.0)**	**49**	**(1.3)**
L01_NSS	31	(1.5)	47	(1.3)
L02_NSS	41	(4.5)	51	(2.6)
L03_NSS	36	(4.4)	51	(3.2)
C_NSS	**30**	**(0.9)**	**55**	**(1.7)**
C01_NSS	25	(1.3)	53	(3.4)
C02_NSS	31	(1.6)	56	(3.1)
C03_NSS	33	(1.5)	57	(2.6)
C_NQSS	**30**	**(1.2)**	**50**	**(1.7)**
C21_NQSS	30	(1.4)	50	(3.3)
C22_NQSS	33	(2.7)	48	(1.9)
C23_NQSS	26	(1.4)	53	(3.5)

Table 3: *Summary of rhythm metrics for all groups*

Groups	LIM_NSS		CUZ_NSS		CUZ_NQSS	
%V	54	(0.9)	50	(0.6)	49	(0.8)
ΔV	31	(2.0)	24	(0.9)	26	(1.3)
ΔC	36	(1.3)	45	(1.9)	44	(2.2)
nPVI-V	39	(1.6)	33	(1.2)	31	(1.3)
rPVI-C	37	(1.4)	45	(2.0)	43	(1.6)
VarcoΔV	36	(2.0)	30	(0.9)	30	(1.2)
VarcoΔC	49	(1.3)	55	(1.7)	50	(1.7)

The analysis of Peruvian Spanish can be compared to previous findings reported in the literature for traditionally stressed, syllable and mora-timed languages. The placement of %V, ΔC and ΔV within the data from Ramus et al [6] for several languages and Frota and Vigário [19] for Brazilian and

European Portuguese (BP and EP respectively) appears in [26]. In sum, the percentage of vocalic sequences for Cuzco and Lima Spanish is higher than that shown in Ramus et al [6] for Spanish and other syllable-timed languages (including French, Italian and Catalan), while the standard deviation of consonants ΔC is lower for both Cuzco groups compared to previous data on Spanish, and even lower for the Lima group; the standard deviation of vocalic sequences for the Lima group is similar to previous data on Spanish while both Cuzco groups show lower ΔV values than the syllable-timed group.

In Figures 1 and 2 the results of the Pairwise Variability Index calculations are shown. Individual speakers from Lima demonstrate higher vocalic values (nPVI-V) compared to Cuzco speakers, while Cuzco speakers show higher degrees of consonantal variation (rPVI-C). In addition, the bilinguals C21-C23 are more closely clustered than the monolinguals C01-C03, who are show a wider range in values. The mean values for these groups are shown with data from Grabe and Lowe [5] in Figure 2. The Lima group shows a higher amount of vocalic variation (nPVI-V) than the Cuzco group and previous Spanish data, while the consonantal variation (rPVI-C) is lower for all Peruvian groups compared to previous Spanish data, with Lima showing the least amount of consonantal variation.

The results for the calculation of VarcoΔC and VarcoΔV appear in Figures 3 and 4 along with %V. Peruvian Spanish groups are shown with the data reported in White and Matthys [13]. VarcoΔC shows a greater separation between Cuzco groups whereas VarcoΔV shows both Cuzco groups to be similar to each other in having lower and more distinct values than the Castillian Spanish in [13]. Nonetheless, the Peruvian Spanish groups appear closer in range to previously reported values for Spanish and French rather than English and Dutch.

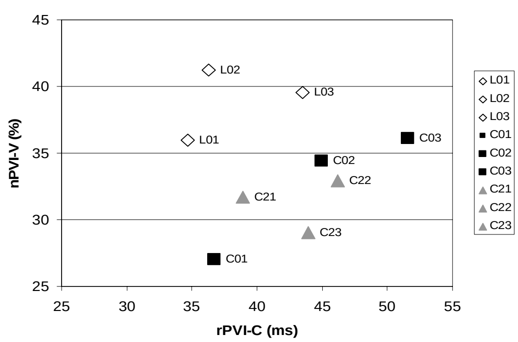

Figure 3: *Vocalic nPVI vs. Consonantal rPVI for Peruvian speakers*

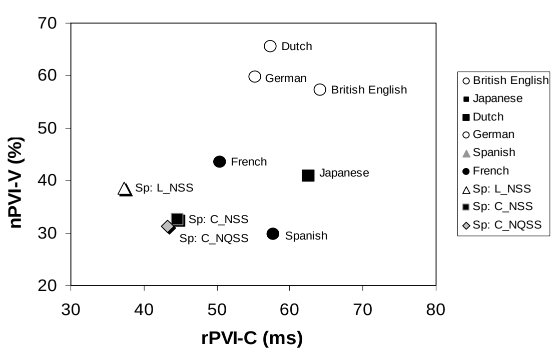

Figure 4: *Average Peruvian PVI values shown with data from Grabe and Lowe [5].*

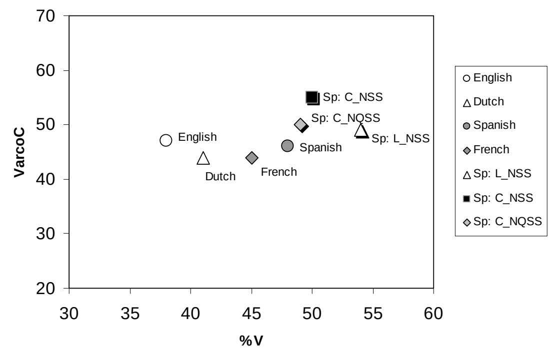

Figure 5: *Peruvian Spanish VarcoΔC vs. %V compared to White and Mattys [13].*

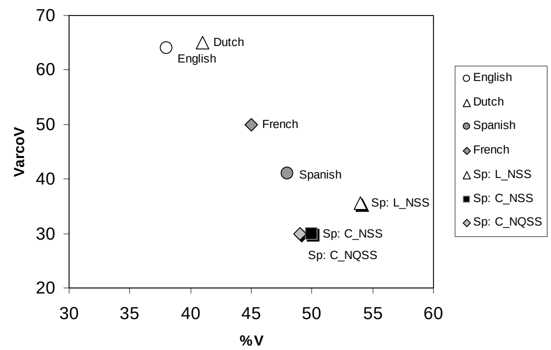

Figure 6: *Peruvian Spanish VarcoΔV vs. %V compared to White and Mattys [13]*

4. Discussion

The differences between Lima and Cuzco groups is readily apparent in the different calculations of rhythm given. In each of these cases, the values for Peruvian Spanish are distinct from those previously reported in the literature. However, the Peruvian Spanish varieties do not trend towards values corresponding to stress-timed languages, but rather are showing less variation in consonants and vowels. Within Peruvian Spanish, the Lima group demonstrates less consonantal variation than Cuzco, and Cuzco groups trend toward less vocalic variation than Lima. In other words, the Cuzco groups are more similar to previous reports on Spanish in terms of vocalic variation (see %V, nPVI-V and VarcoΔV in Table 3), whereas Lima is more similar in terms of consonantal variation (see VarcoΔC); still non-normalized scores show a greater separation of the Lima group from the literature in terms of consonantal variation (see ΔC, rPVI-C).

Statistical analysis of variance shows significant differences between the three Peruvian Spanish groups: %V [$F(2,173)=14.36$, $p<0.01$]; ΔC [$F(2,173)=6.38$, $p<0.01$]; ΔV [$F(2,172)=10.19$, $p<0.01$]; nPVI-V [$F(2,173)=7.99$, $p<0.01$]; rPVI-C [$F(2,173)=5.16$, $p<0.01$]; VarcoΔV [$F(2,173)=5.82$, $p<0.01$]; VarcoΔC [$F(2,173)=4.68$, $p<0.05$]. Posthoc Tukey/Kramer tests show significant differences at $p<0.05$ level between the Lima and the two Cuzco groups; however, significant differences are not observed between the two Cuzco groups for the rhythm metrics listed above. In addition, no significant difference in consonantal variation is observed between LIM_NSS and CUZ_NQSS groups for both ΔC and VarcoΔC. Therefore, while differences in origin between Lima and Cuzco can be observed, knowledge of Quechua as a native bilingual speaker does not result in the use of significantly different rhythm patterns from the monolingual native Spanish speakers in Cuzco. In fact, the difference in origin seems to lie in the more distinct nature of Lima rhythm compared to Cuzco Spanish and other Spanish varieties in the literature. This difference is consistent with other innovative features of Lima Spanish, such as /s/-aspiration and deletion [27, 28], which would result in a greater percentage of overall vocalic sequences.

5. Conclusions

This paper has been offered as an attempt to observe variation in Spanish speech rhythm. As shown, the consonantal and vocalic variation in Peruvian Spanish is distinct from that reported previously in the literature. The rhythm metrics employed demonstrate slightly different results but still show some of the same overall trends. That is, the vocalic sequences for Peruvian Spanish were shown to be higher in percentage than those reported in the literature while consonantal variation in general was lower. Between Lima and Cuzco, some differences can be observed, although the Cuzco bilingual and monolingual Spanish groups themselves were not significantly different. This finding is in keeping with [21] who found target-like attainment of distinct rhythms in Spanish and English bilingual adults. Future research in Quechua-Spanish prosodic contact may examine the extent to which native Quechua speakers who learn Spanish later achieve the same results as the native bilinguals shown here. Also, the nature of Quechua rhythm itself needs to be explored to determine how different the speech rhythm is for Peruvian speakers of Spanish and Quechua.

The present study has shown that, while previously Spanish has been taken as a prototypical syllable-timed language, a wider range of possible speech rhythms was observed for Peruvian Spanish, pointing to the need for further cross-dialectal research. Although it may be too early to determine if additional rhythm classes should be posited or whether this data set argues for considering rhythm to exist along a continuum, these data do at least question the limits of the syllable-timed grouping according to the acoustic measures used. In addition, while contact with other languages may be a potential area where alternate rhythms may develop, other varieties considered more phonetically innovative may also employ a distinct rhythm as was observed in the case of Lima Spanish.

6. References

[1] Pike, K.L. 1945. *The Intonation of American English*. Ann Arbor: University of Michigan Press.

[2] Abercrombie, D. 1967. *Elements of General Phonetics*. Chicago: Aldine.

[3] Ladefoged, P. 1975. *A Course in Phonetics*. ed., ed. Vol. New York: Harcourt Brace Javanovich.

[4] Dauer, R.M. 1983. Stress-timing and syllable-timing reanalyzed. *Journal of Phonetics* 11, 51-62.

[5] Grabe, E. and E.L. Low. 2002. Durational variability in speech and the Rhythm Class Hypothesis. In: C. Gussenhoven and N. Warner, (eds.), *Papers in Laboratory Phonology 7*, Moutin de Gruyter: Berlin, 515-546.

[6] Ramus, F., M. Nespor, and J. Mehler. 1999. Correlates of linguistic rhythm in the speech signal. *Cognition* 73, 265-292.

[7] Lowe, L., E. Grabe, and F. Nolan. 2000. Quantitative characterizations of speech rhythm: Syllable-timing in Singapore English. *Language and Speech* 43.4, 377-401.

[8] Asu, E.L. and F. Nolan. 2005. Estonian rhythm and the Pairwise Variability Index. *Proc. Fonetik* Göteborg University, 29-32.

[9] Barry, W.J., et al. 2003. Do rhythm measures tell us anything about language type? *Proc. 15th ICPhS* Barcelona, 2693-2696.

[10] Dellwo, V. and P. Wagner. 2003. Relations between language rhythm and speech rate. *Proc. 15th ICPhS* Barcelona, 471-474.

[11] Dellwo, V. 2006. Rhythm and speech rate: A variation coefficient for ΔC. *Language and Language Processing: Frankfurt: Peter Lang.*, 231-241.

[12] White, L. and S.L. Mattys. 2007. Calibrating rhythm: First language and second language studies. *Journal of Phonetics* doi:10.1016/j.wocn.2007.02.003.

[13] White, L. and S.L. Mattys. 2007. Rhythmic typology and variation in first and second languages. In: P. Prieto, J. Mascaró, and M.-J. Solé, (eds.), *Segmental and Prosodic issues in Romance Phonology*, John Benjamins: Amsterdam.

[14] White, L., et al. 2007. Rhythm metrics predict rhythmic discrimination. *Proc. 16th ICPhS* Saarbrücken, Germany, 1009-1012.

[15] Dellwo, V., A. Fourcin, and E. Abberton. 2007. Rhythmical classification of languages based on voice parameters. *Proc. 16th ICPhS* Saarbrücken, Germany, 1129-1132.

[16] Ling, L.E., E. Grabe, and F. Nolan. 2000. Quantitative characterizations of speech rhythm: Syllable-timing in Singapore English. *Language and Speech* 44.3, 377-401.

[17] Jian, H.-L. 2004. On the syllable timing in Taiwan English. *Proc. Speech Prosody* Narra, Japan, 247-250.

[18] Ghazali, S., R. Hamdi, and M. Barkat. 2002. Speech rhythm variation in Arabic dialects. *Proc. Speech Prosody* Aix-en-Provence, France, 331-334.

[19] Frota, S. and M. Vígario. 2001. On the correlates of rhythmic distinctions: The European/Brazilian Portuguese case. *Probus* 13, 247-275.

[20] Ramus, F. 2002. Acoustic correlates of linguistic rhythm: Perspectives. *Proc. Speech Prosody* Aix-en-Provence, France, 115-120.

[21] Bunta, F. and D. Ingram. 2007. The acquisition of speech rhythm by bilingual Spanish- and English-speaking 4- and 5-year-old children. *Journal of Speech, Language, and Hearing Research* 50, 999-1014.

[22] Alonso, A. 1940. La interpretación araucana de Lenz para la pronunciación chilena. In: A. Alonso, Editor, *El español de Chile*.

[23] Henríquez Ureña, P. 1938. *El español en Méjico, los Estados Unidos, y la América Central*. Buenos Aires: Universidad de Buenos Aires.

[24] Malmberg, B. 1948. L'español dans le nouveau monde -- Probléme de linguistique générale. *Studia Linguistica* 1, 1-74.

[25] O'Rourke, E. 2005. Intonation and language contact: A case study of two varieties of Peruvian Spanish. Doctoral Dissertation, University of Illinois at Urbana-Champaign.

[26] O'Rourke, E. In press. Correlating speech rhythm in Spanish: Evidence from two Peruvian Spanish dialects. *Proc. Hispanic Linguistics Symposium* Western Ontario, London, Ontario (Canada).

[27] Escobar, A. 1978. *Variaciones sociolingüísticas del castellano en el Perú*. Lima: Instituto de Estudios Peruanos.

[28] Caravedo, R. 1983. *Estudios sobre el español de Lima: Variación contextual de la sibilante*. Lima, Peru: Fondo Editorial de la Pontificia Universidad Católica del Perú.