SEGMENTAL ASPECTS OF SPEAKERS WITH PARKINSON'S DISEASE

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ABSTRACT

In this study, we propose to explore the segmental aspects of the speech production of a Brazilian Parkinsonian group. Three spectral moments - mean (m_1), skewness (m_3) and kurtosis (m_4) - and vowel space area were measured. A total of 8 subjects participated in the study, including 5 parkinsonians with dysarthria and 3 healthy subjects. The experimental task was sentence reading. For acoustic analysis, we selected the words containing the voiceless stop /p,t,k/ at word onset, followed by /a/, and the lexically stressed vowels /i, a, u/.

The results suggest that the values for all three spectral moments were higher compared to the healthy subjects. The spectral moment distribution analysis showed that three parkinsonians were able to distinguish places of articulations whereas two parkinsonians did not distinguish place of articulation; by contrast all the control participants control did. For vowel production, our results point to great intersubject vowel space variability expressed by higher values for variance in the parkinsonian group.

Keywords: acoustics, dysarthria, parkinson's disease, phonetics

1.INTRODUCTION

Parkinsonian dysarthria is described in the literature as being hypokinetic [4]. Articulation imprecision is one of its main characteristics. Canter [2] pointed to three main segment features: spirantizantion during stops consonants; devoicing of voiced consonant in intervocalic context, and omission of liquids at the beginning of words. Longemann & Fisher [7] reported that the misarticulations present in parkinsonian speech were the result of articulatory undershoot, that is, the incomplete closure of the articulatory gesture, suggesting that the combination of neurogenic weakness and acceleration produces undershoot. Ackermann & Ziegler [1] studied the dynamics of articulatory production. They pointed to the maintenance of the time frame coupled with reduction in articulatory precision in stop consonants, leading to the amplitude reduction of the articulatory movements. They demonstrated that the misarticulations were not homogeneous throughout speech, varying according to suprasegmental aspects of the sentence. This fact indicates that motor difficulties inherent to the pathology are repaired with reference to the linguistic restrictions of the language. Mc Rae et all. [8] investigated the production of English vowels, /I, u, ɑ/ at different speech rates. They showed that the vowel space was reduced independently of speech rate. Tjaden et all. [13] followed up the study evaluating the behavior of the vowels /ɑ, e, æ, O), considering the hypothesis that these vowels would not be affected by dysarthria as they are already in the center of the vocalic space. However, the results showed larger centralization in the parkinsonian population than in the control group. Rosen et all. [10] studied different speech tasks and concluded that hypokinetic dysarthria is consistently distinct from the speech of healthy speakers in repetition and conversation tasks, measuring intensity variation and spectral range. However, although the parkinsonian group was able to reach maximum levels of contrast in the repetition of sentences, they did not carry it through in its habitual production.

Despite the studies focused on describing parkinsonian dysarthria in English speakers, there are very few studies on parkinsonian Brazilian Portuguese (BP) speakers. Most of them are concerned with prosodic aspects of this group's speech [3, 11].

Spectral moments can be used to characterize normal and disordered speech [5, 9]. As defined by Forrest et all. [5] the spectral envelope is treated as a probability density function and the first four moments of this function (mean, variance, skewness and kurtosis) are used in the noise analysis, providing information about the dynamic features of a speech segment.

The first vowel formants (F1 and F2) can reflect the pattern of vowel articulation. The literature points out that the vowel dispersions in hypokinetic dysarthria are reduced [13, 14]. Soares [12] found similar results in BP by analyzing the dispersion of vowel formants, but was not able to obtain statistical significance for her data by comparing formant values of parkinsonians with controls. The measurement of the vowel space in Hz promises to be an efficient way to compare vowel dispersions.

In this study, we propose to explore the segmental aspects of the speech production of a Brazilian parkinsonian group. This experiment was designed to answer the following questions: - 1) Are spectral moments useful to describe voiceless stop production in parkinsonian patients? - 2) Do spectral moments differ between parkinsonians and the control group? - 3) Can vowel dispersion be evaluated by vowel space area?

2.METHODOLOGY

2.1.Subjects

A total of 8 subjects participated in this study, including 5 parkinsonians with dysarthria and 3 healthy subjects. The PD group consisted of 5 men ranging in age from 39 to 72 (med 65), onset time of the disease ranging from 2 to 10 years (med 8), and each one at a different stage of the disease, according to Hoehn & Yard [6] scale (S_1: degree I; S_2: degree II; S_3: degree III; S_4: degree III and S_5: degree IV). The control group included 3 men ranging in age from 64 to 80 (med 70). The parkinsonian group was under neurological treatment and taking antiparkinsonian medications. All participants were Brazilian and could read and write. None of the participants reported hearing deficits. The control group reported no known speech and hearing deficits or history of neurological pathology or any kind of communications disturbances; and reported no history of neurological disease.

2.2.Procedures

Twenty sentences were read by all participants. The target sentences were presented in random order. The task was repeated five times, totalling one hundred sentences. The reading was recorded on a MD Sony, MZ R 91 Model, using a professional Le Son unidirectional-head microphone. The data were analyzed acoustically using the Praat software, version 4. 5.15.

In this study, we focused on the voiceless stops / p, t, k / and on the three lexically stressed vowels / i, ɑ, u /. We kept the influence of the following vowel constant by having the voiceless stop targets in word onset position followed by the vowel /ɑ/. All vowel targets were in lexically stressed position. There were five repetitions of each stop target and ten of each vowel target. VOT had been measured and their average values were respectively; /p/: 31.738, /t/: 34.955, /k/: 45.709 for the parkinsonian group; and /p/: 24.74, /t/: 29.659 and /k/: 32.711 for the control group. None of the VOTs was lesser than 20ms.

The spectral moment were calculated using single 20ms full Hammimg window placed at the beginning of the burst release. We used only three moments to describe the stop productions, as suggested by Forrest [5]: mean (m_1), skewness (m_3) and kurtosis (m_4).

The vowels formants were measured by LPC spectrographic analysis, with settings adjusted for each sample. Formants values were averaged for each vowel. The vowel space area (expressed in Hz^2) was calculated by measuring the triangle area for each participant.

3.RESULTS

3.1 – Spectral Moments

An ANOVA analysis was carried out with consonant place of articulation as the independent variable ($p<0.05$). All average values for m_1, m_3 and m_4 were higher for the parkinsonian group compared for the control group as shown in tables 1, 2 and 3, results for m_1, m_3 and m_4, respectively.

These spectral moments (m_1, m_3, m_4) were overall sufficient to distinguish among the three places of articulation for voiceless stops in the control group. In the parkinsonian group S1, S2 and S3, showed significant difference at m_1 and m_3; for m_4 only S1 and S2 showed significant differences among the consonants. The other two parkinsonians, S4 and S5, did not show any evidence of distinguishing consonant place of articulation through spectral moments.

The triangle areas of F1 and F2 averages were plotted as show in figures 1 and 2. The values for each group were analyzed separately, through an independent test-t. The results were significantly different for the parkinsonian group -$T_{(4)} = 4{,}183$, p= ,013 - and not statistically significantly for control group.

Table 1: ANOVA and descriptive results for parkinsonian (S_n) and control (C_n) subjects for m_1

	F	p	$\bar{\chi}$			σ		
			/p/	/t/	/k/	/p/	/t/	/k/
S1	10. 7	*.00*	328	504	1240	77. 8	272	507
S2	48. 1	*.00*	155	362	1124	519	115	17. 8
S3	8. 6	*.01*	301	1192	682	129	1130	744
S4	1. 4	.28	221	336	1059	117	132.3	609
S5	2.3	.16	288	438	851	39. 2	442	675
C1	9. 2	*.00*	220	305	118.3	77. 8	188	126
C2	5. 7	*.02*	241	406	739	98. 3	184	308
C3	49. 7	*.00*	301	307	1068	32. 7	27. 6	238

Table 2 ANOVA and descriptive results for parkinsonian (S_n) and control (C_n) subjects for m_3

	F	p	$\bar{\chi}$			σ		
			/p/	/t/	/k/	/p/	/t/	/k/
S1	10.3	*.00*	11. 6	7. 5	5. 7	2. 3	3. 0	2. 5
S2	6.1	*.00*	19. 6	9. 6	5. 8	11. 4	1. 9	1. 4
S3	7.0	*.01*	14. 6	5. 4	12. 4	6. 5	3. 3	7. 3
S4	3.8	.06	10. 1	6. 7	4. 0	4. 3	3. 4	2. 7
S5	2. 8	.11	14. 2	9. 3	6. 4	3. 8	5. 9	3. 4
C1	50.1	*.00*	14. 7	12. 3	15. 8	3. 0	7.9	1. 1
C2	8.1	*.00*	11. 6	6. 9	4. 7	3. 8	2. 8	0. 7
C3	12.3	*.00*	7. 8	8. 1	4. 6	2. 0	1. 8	0. 8

Table 3 ANOVA and descriptive results for parkinsonian (S_n) and control (C_n) subjects for m_4

	F	p	$\bar{\chi}$			σ		
			/p/	/t/	/k/	/p/	/t/	/k/
S1	7. 5	*.01*	220	98. 1	51. 2	103. 7	45. 9	47. 7
S2	2. 6	.13	735	135	54.5	893. 3	53. 4	16. 6
S3	4. 6	*.04*	339	51. 8	404.1	276.2	46. 7	435. 9
S4	2. 7	.12	198	66. 5	40.6	168.5	73. 1	62. 2
S5	0. 9	.44	170	154.1	77.2	78.5	192. 1	87. 9
C1	56. 8	*.00*	347	294.2	65.9	128. 4	314.1	48. 9
C2	6. 7	*.01*	213	69. 2	33. 9	119. 2	66. .3	11. 8
C3	4.5	*.04*	102	96. 3	48. 7	42. 1	47. .3	41. 1

* Significant results are in italic font

Figure 1: F1 and F2 averages for vowels /i, a, u/ , for parkinsonian subjects

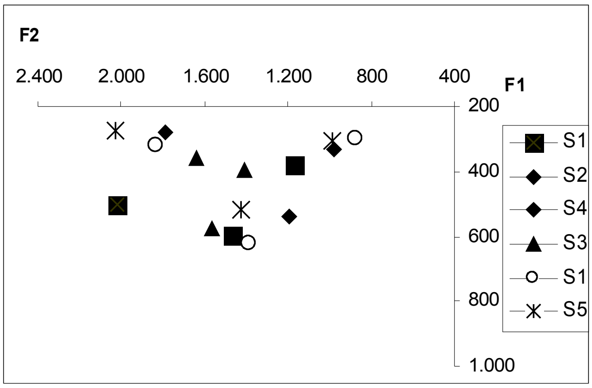
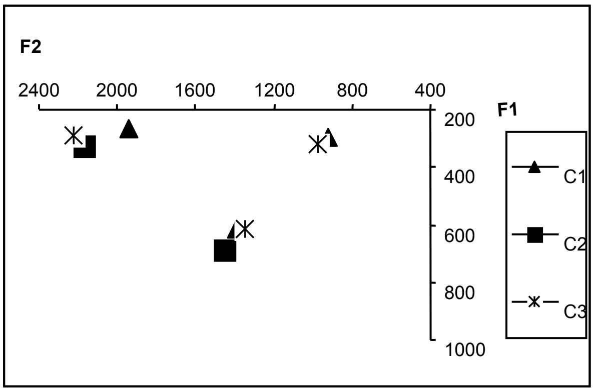


Figure 2: : F1 and F2 averages for vowels /i, a, u/ , for control subjects



Note: It is possible to make a triangle binding the corresponding vowel points for each subject

4 – DISCUSSION

We proposed to evaluate the energy distribution in a FFT window in order to compare voiceless stop consonants productions in the two groups – parkinsonian and control–. A qualitative spectrographic analysis suggested a different display. The stop bursts differ in four different configurations: 1) a higher energy solid bar; 2) a low energy bar; 3) multiple burst releases and 4) burst preceded by aspiration-like noise. These configurations show some differences in acoustic parameters. It is clear that the energy distributions were distinct between the two groups. The values for all three spectral moments were higher in the parkinsonian group as compared to the healthy subjects. The reductions of the articulator movements may reflect higher energy distributions. With these results we can infer that the parkinsonian group uses mostly the anterior portion of the oral cavity. Considering the articulatory place distinction, the result suggests that all the participants of the control group were able to distinguish places of articulation by the spectral moment analyses. The control subjects showed an overall statistically significant difference but a pos-hoc test (Scheffé) revealed that not all contrasts can be established. It is important to note that we do not have much information, in the literature, describing patterns of speech production in the elderly population, especially when quantified by spectral moments. We have to consider that the elderly population can be affected by some loss of articulatory precision. The results of the parkinsonian group suggest that during the course of the disease the possibly articulatory contrastivity becomes worse. We found different results related to stage of the disease, although we could not corroborate it statistically because of the small sample. Three parkinsonians – S1, S2 and S3 – were able to distinguish consonant place of articulation through spectral moment analysis, in a different way from that of the control group. The other two parkinsonians – S4 and S5 – did not present such distinctions. Interestingly these two subjects were at a more severe stage of the disease. There are other acoustic parameters which can be used as cues for such distinctions, and the parkinsonian subjects could be using them. We intend to incorporate other parameters to the analysis in a future study.

For vowel production, our results pointed to great intersubject vowel space variability expressed by higher values for variance in the parkinsonian group. These results can indicate the different patterns of articulatory compensation relative to different impacts of the disease. The control group showed no significant intersubject differences for vowel space area as expected.

5. CONCLUSIONS

The present investigation shows that spectral moments can be useful to describe voiceless stop consonants in a group with PD. The results indicate differences and similarities in the spectral characteristics of consonants produced by parkinsonian and healthy subjects. Despite the absence of statistical comparison, the qualitative analysis of the data suggested that the spectral moments may differ between the groups. Finally, the area of the vowel space has proven to a sensitive measure to compare vowel dispersion. The results show statistically significantly differences within the parkinsonian group and no statistically significant differences within the control group.

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