

# *Fundamental frequency change rate and dialect contact*

*A study on the prosody of internal migrants in Brazil*

Gustavo de Campos P da Silveira  
Instituto de Estudos da Linguagem  
Universidade Estadual de Campinas  
Campinas, Brazil  
silveira@tuta.io

**Abstract:** This paper reports partial results from a study on the prosody of Northeastern Brazilian migrants living in the Southeastern state of São Paulo. Previous works on the speech of this migrant community show that the speaker's age of arrival in São Paulo can predict the successful acquisition of Paulista segmental variables. However, their findings do not reach the suprasegmental domain of speech. The prosody of migrants in dialect contact situations has not received enough attention to draw more general conclusions about if and how prosodic patterns can change due to long-term exposure to a different regional variety. We examine fundamental frequency change rates in semi-spontaneous utterances by 23 adult migrants from the Northeastern state of Alagoas living in Campinas city (São Paulo), in contrast with a control sample by nine life-long native residents of Campinas. Mixed-effects linear models, including speaker as a random variable, show that the fundamental frequency of male Alagoan migrants rises and falls faster than male Campineiros. The models also suggest a negative correlation between the age of arrival and the rates of change. Male migrants who moved to Campinas before the age of 20 have slower change rates that do not statistically differ from native Campineiros. In turn, we observe that those over the age of 20 when migrating have faster change rates, significantly differing from the natives. These partial results, thus, suggest that the age of arrival is a factor that can help to predict the degree of prosodic accommodation in dialect contact settings.

*Intonation; fundamental frequency change rate; prosodic accommodation; dialect contact; Brazilian Portuguese.*

## I INTRODUCTION

In an increasingly connected world, geographical mobility is a central piece in the dynamics of most urban settings, and one consequence of mobility is the contact between speakers of different regional varieties of the same language. Dialect contact is a complex phenomenon whose effects are not yet fully understood [6, 9]. At the individual level, long-term interactions between speakers from different dialectal regions can cause modifications in their speech, a phenomenon that some researchers have called dialect accommodation [16] while others have preferred to name it dialect acquisition [5]. At the community level, the influence that varieties in contact exert upon each other can be the source of linguistic changes [16, 13].

The speech of migrant communities can provide a fertile ground to investigate to what extent adult speakers can have their speech patterns changed due to dialect contact. However, as Oushiro [11] pointed out, studying the speech of migrants can be challenging since a large number of social factors can influence it, such as speakers' age of arrival, length of residence in the new community, social network, regional identities, among others.

Recent studies on the speech of internal adult migrants from Northeast Brazil living in the Southeastern state of São Paulo [11, 12] have shown that migrants' age of arrival is a predicting factor of their success in acquiring some of the salient variants of the Paulista variety. These studies observed a negative correlation between the speaker's age of arrival and the pronunciation of coda /t/ (e.g., *porta* 'door' as [ˈpɔɾ.tɐ] or [ˈpɔɪ.tɐ] instead of [ˈpɔx.tɐ]), the affrication of

/t/ and /d/ before [i] (e.g., *tia* 'uncle' as [ˈtʃi.ɐ] instead of [ˈti.ɐ]), and the raised pronunciation of the pretonic mid vowels /e/ and /o/ (e.g., *relógio* 'clock' as [hɛ.ˈlɔ.ʒiɔ] instead of [hɛ.ˈlɔ.ʒiɔ]). Although they have also analyzed the

---

This study is supported by a grant from the Coordination for the Improvement of Higher Education Personnel (CAPES 88887.495348/2020-00).

length of residence in São Paulo, this factor correlated only with coda /r/, proving to be less effective as a predictor of dialect acquisition of segmental variables.

Even though these studies have contributed to understanding the effects of dialect contact on the speech of internal migrants in Brazil, their results do not reach speech prosody. Compared to segmental ones, suprasegmental parameters have received much less attention from sociophonetic studies [15]. Thus, it is still a question to know if the patterns of dialect accommodation observed by segmental studies also apply to suprasegmental features.

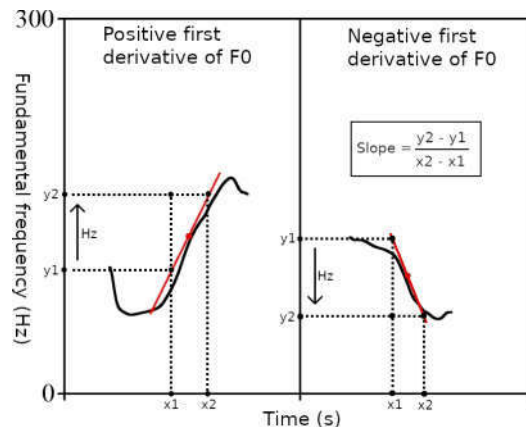


Figure 1. Rising (on the left) and falling (on the right) fundamental frequency contours (in black), and the tangent line (in red) to a point in those contours. The first derivative at the point is the slope of the tangent line.

This paper reports partial results from an ongoing study on the prosody of internal migrants from Alagoas (Northeast Brazil) living in the Metropolitan Region of Campinas in São Paulo. We examine four acoustic parameters concerning the fundamental frequency (F0) change rate. First-order derivatives (i.e., the slope of the tangent line to a point in a function's graph) represent the rate of change of one variable in relation to another one. The first derivative tells us if the F0, in the y-axis, is increasing (when its slope is a positive number) or decreasing (when it is a negative number) along the time in the x-axis (see Figure 1). It also tells us how fast F0 is changing. The magnitude of the derivative in absolute value indicates by how many Hertz the fundamental frequency changes per unit of time. The four acoustic parameters analyzed in this study are the mean and the standard deviation of positive and negative first derivatives of F0. The measurement unit is Hertz per 50 milliseconds (Hz/50ms). We hypothesized that the younger the Alagoan speakers when they migrate to Campinas, the smaller the difference between them and life-long Campineiros in F0 change rates.

## II METHODOLOGY

We analyze speech recordings from two corpora collected by other researchers in previous projects. One is the ALCP sample collected by Oushiro [11]. It comprises recordings of 23 adult Alagoan migrants living in Campinas, balanced for gender (females; males) and age of arrival (before 20 years old; 20 or more years old). The other is the CPS sample collected by Natasha Mourão. Composed of recordings of nine life-long native speakers from Campinas and balanced for gender (females; males), this sample serves as a control. The speakers of both corpora were recorded in a one-hour-

long sociolinguistic interview. Therefore, the data analyzed here represent a semi-spontaneous style of speech, according to Barbosa's speech style typology [1].

Time-aligned transcriptions of all recordings were made by the researchers responsible for the corpora, using the software ELAN [14]. To obtain reliable acoustic measurements of F0 change rates, we developed a set of semi-automatic procedures to select and extract small samples from the transcribed recordings. We call these samples by chunks and define them as any piece of the original audio containing only the participant's speech, delimited by silent pauses and ranging from four to seven seconds of duration. We developed a program in the Python programming language to parse the transcription files and, based on time-related information contained in these files, to automatically identify and extract the chunks.

The program extracted 4,433 audio files, each corresponding to a single chunk, from the ALCP and CPS samples. For the analysis reported here, a smaller subset of 640 chunks (20 by each participant) was randomly selected for manual revising in Praat [4]. We checked if they meet the criteria described above and correspond to meaningful utterances ending in a prosodic boundary. If a chunk did not meet these criteria, we replaced it with another randomly selected one by the same speaker.

The automated F0 tracking in Praat depends on setting a frequency range (named pitch range by the developers), a parameter that largely influences the accuracy of the F0 measurements. However, the optimal range can vary considerably between speakers and within the speech of the same speaker [3]. For this reason, in this study, the frequency range of each chunk was defined manually and case by case, trying to reduce as much as possible measurement errors observed in the F0 contour.

A modified version of the Prosody Descriptor Extractor, a Praat script developed by Barbosa [2], automatically computed the F0 change rates. Besides many other acoustic parameters, Barbosa's script extracts the mean and the standard deviation of the positive and negative first derivatives of F0 from each chunk and exports the measurements to a tabular text file that statistical programs can read. Instead of computing the acoustic parameters based on a global frequency range for all chunks, the modified version of the script allows each chunk to have its own frequency range.

In this paper, we examine mixed-effects linear regression models contrasting the F0 change rates of three groups of speakers: (i) Alagoan migrants that moved to Campinas at a younger age (19 years old or younger); (ii) Alagoan migrants that migrated at an older age (20 years old or older); (iii) and native life-long speakers from Campinas (control group). Our purpose is to determine if the magnitude of the difference between Alagoan migrants and native Campineiros in the F0 change rates correlates with the migrants' age of arrival in Campinas. The data were analyzed using the R programming language.

### III RESULTS

Male and female speakers are analyzed separately to avoid the effects of anatomical-related differences between genders. Figure 2 shows density plots representing the distribution of the four F0 change rate parameters, contrasting speakers' age of arrival. The control sample is also included for reference. Plots from A to D refer to females, while the ones from E to H refer to males. The vertical bars indicate the arithmetic mean of each group.

Figure 2 shows that the distributions of the F0 change rates in the three groups of female speakers overlap almost completely. Female speakers who moved to Campinas under the age of 20 show a slightly higher mean of the standard deviation of negative F0 change rate. However, this difference is not statistically relevant (see Table 1). We observe a higher dispersion among male Alagoan migrants contrasted to male native Campineiros. On average, their fundamental frequency has a faster rate of change both in the F0 rises and falls (plots E and F). The standard deviation of F0 change rates is also higher among male migrants (plots G and H). It is important to notice that the speakers who migrated at a younger age have distributions closer to the control group.

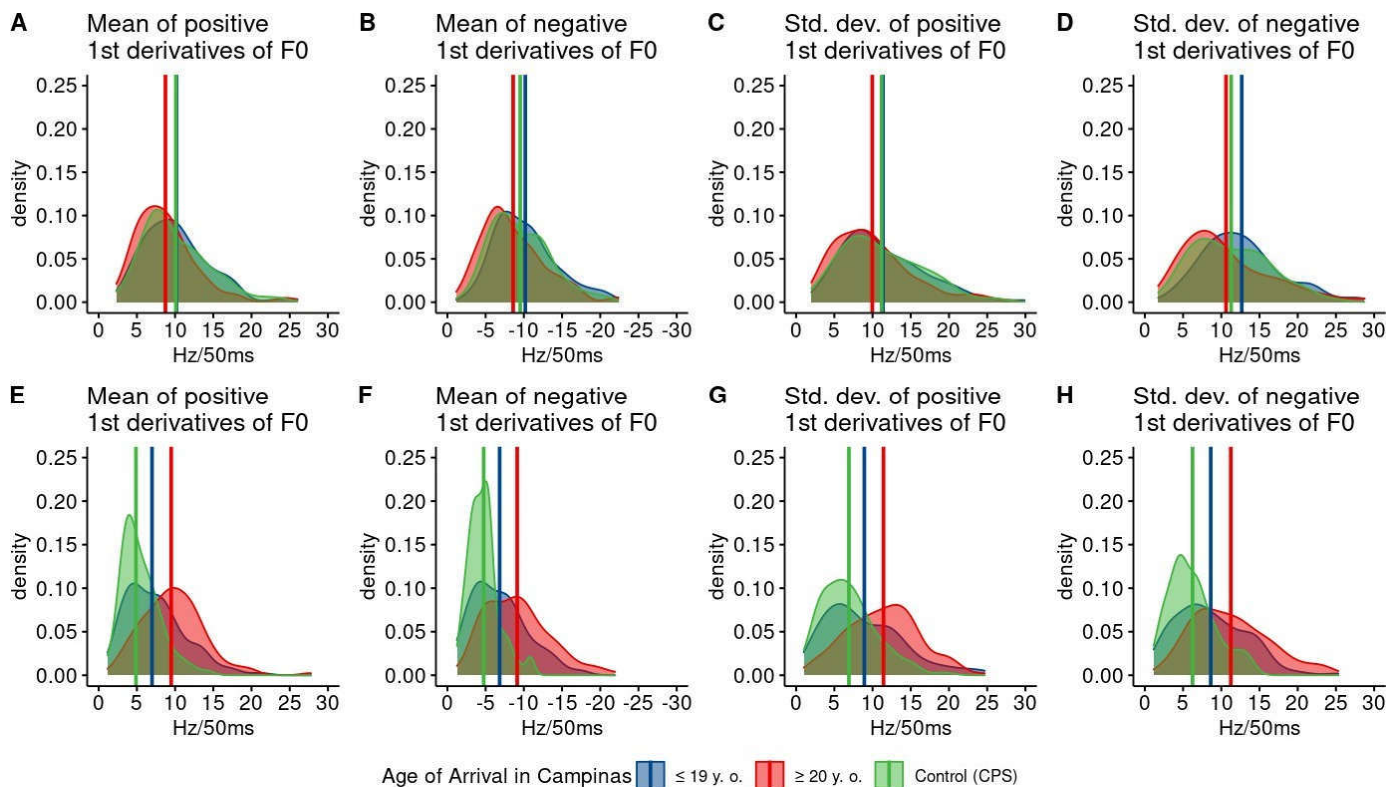


Figure 2. Distribution of the fundamental frequency change rates (Hertz per 50 milliseconds) for female (from A to D) and male speakers (from E to H) according to the age of arrival in Campinas. The control group is also shown for reference.

Table 1 reports eight mixed-effects linear regression models of the four F0 change rate parameters for both genders. All share the same predictor variable, i.e., the age of arrival in Campinas, and have the speaker as a random variable. We also include the control sample in the models, coded as a single factor of the predictor variable, to estimate how close the Alagoan migrants are from native Campineiros in F0 change rates. The control group is the Intercept of the models,

i. e., the reference value to which the other levels of the predictor variable are compared. The two rows below the Intercept bring the relative estimate to the Intercept. The asterisks beside the relative estimates indicate that the difference from the Intercept is statistically significant under an alpha level ( $\alpha$ ) of 0.05. Table 1 also reports the estimated standard deviation of the random effects and the coefficients of determination (R<sup>2</sup>) of each model. Marginal R<sup>2</sup> measures the percentage of the variance explained by fixed effects alone (i.e., the age of arrival), while conditional R<sup>2</sup> also includes the random effects (i.e., the speaker).

TABLE I. MIXED-EFFECTS LINEAR REGRESSION MODELS OF THE MEAN AND THE STANDARD DEVIATION OF POSITIVE AND NEGATIVE FIRST DERIVATIVES OF THE FUNDAMENTAL FREQUENCY CONTRASTING THREE GROUPS OF SPEAKERS: (I) NATIVE LIFE-LONG SPEAKERS FROM CAMPINAS (CONTROL); (II) ALAGOAN MIGRANTS WHO MOVED TO CAMPINAS UNDER THE AGE OF 20; (III) ALAGOAN MIGRANTS WHO MOVED TO CAMPINAS OVER THE AGE OF 20. THE SPEAKER IS INCLUDED AS A RANDOM VARIABLE.

Female speakers (N = 289 chunks)					
		Mean of positive first derivatives of F0 (Hz/50ms)	Mean of negative first derivatives of F0 (Hz/50ms)	Std. deviation of positive first derivatives of F0 (Hz/50ms)	Std. deviation of negative first derivatives of F0 (Hz/50ms)
<b>R<sup>2</sup></b>	<i>Marginal R<sup>2</sup></i>	2%	2%	1%	2%
	<i>Conditional R<sup>2</sup></i>	16%	12%	19%	5%
<b>Estimates</b>	<i>Intercept (Control group)</i>	10.1	-9.5	11.1	11.3
	<i>Age of Arrival: ≤ 19 y. o.</i>	+ 0.01	- 0.6	+ 0.1	+ 1.4
	<i>Age of Arrival: ≥ 20 y. o.</i>	- 1.3	+ 0.9	- 1.1	- 0.5
<i>Standard deviation</i>					
<b>Random effects</b>	<i>Speaker</i>	1.6	1.3	2.2	1.9
	<i>Residual</i>	3.9	3.8	4.8	5.1
Male speakers (N = 356 chunks)					
<b>R<sup>2</sup></b>	<i>Marginal R<sup>2</sup></i>	15%	18%	13%	17%
	<i>Conditional R<sup>2</sup></i>	39%	40%	39%	38%
<b>Estimates</b>	<i>Intercept (Control group)</i>	5.5	- 4.7	6.9	6.2
	<i>Age of Arrival: ≤ 19 y. o.</i>	+ 1.9	- 2.2	+ 2.04	+ 2.4
	<i>Age of Arrival: ≥ 20 y. o.</i>	+ 4.9 *	- 5.02 **	+ 4.8 *	+ 5.7 **
<i>Standard deviation</i>					
<b>Random effects</b>	<i>Speaker</i>	2.6	2.2	2.8	2.6
	<i>Residual</i>	4.1	3.7	4.3	4.4

\*: p < 0.05, \*\*: p < 0.001, \*\*\*: p < 0.001

From Table 1, it becomes clear that there is no relevant difference between female Alagoan migrants and female native Campineiras concerning F0 change rates. The F0 of the three groups rises and falls at an average of 10 Hz/50ms. Female speakers also show similar dispersion measures, with the F0 change rates varying on average 11 Hz/50ms. The age of arrival accounts for no more than 2% of the variance explained by the models (marginal RZ). Even with the inclusion of the random effects, the explained variance does not reach values higher than 19% (conditional RZ).

The difference between Alagoan migrants and native Campineiros is higher among men. Both groups of migrant speakers show higher values (in absolute terms) than the control group in all parameters. Descriptively, the fundamental frequency of male Alagoans rises and falls faster than that of the natives Campineiros. However, these differences are not statistically relevant in the case of the speakers who migrated before the age of 20. In turn, the speakers who moved to Campinas when they were 20 years old or older statistically differ from the control group in all F0 change rate parameters.

The models of male speakers also show higher explanatory power than those of female ones. However, even in the case of male speakers' models, the age of arrival alone does not explain much of the variance in the F0 change rate values. The best model refers to the mean of the negative first derivatives of F0. The age of arrival explains 18% of the

variance in this parameter (marginal RZ). The inclusion of the speaker (i.e., the random variable) increases the model's explanatory power to 40%, an increment of 22% that surpasses the contribution of the age of arrival.

#### IV DISCUSSION

Previous studies show that speakers' age of arrival is a factor that contributes to the prediction of the successful acquisition of segmental variables. The younger the speakers when they migrate, the bigger their success in acquiring the segmental features of the new community. The results reported here partially confirm this correlation for a prosodic variable, i.e., the change rates of fundamental frequency in the speech of Alagoan migrants living in Campinas.

Table 1 reveals that female and male Alagoan migrants have different behaviors. The age of arrival does not seem to influence the F0 change rates of female Alagoans migrants. Oppositely, this social factor correlates with F0 change rates of male migrants. The distance from the native Campineiros decreases for the speakers who arrived in Campinas at a younger age. One possible interpretation is that female Alagoans accommodate faster to the prosody of Campinas than male Alagoans. In other words, the absence of differences among female speakers can be evidence that a complete prosodic accommodation took place. In turn, male Alagoans seem to be more resistant to new prosodic patterns, especially those who migrated at an older age.

Sociolinguists [13] usually explain the effects of the age of arrival based on Lenneberg's critical period hypothesis [7], according to which the speaker's linguistic system stabilizes after a certain age and becomes less susceptible to changes. Extending this argument to prosody, the patterns observed in the speech of males can be interpreted. The ones who arrived before adulthood have a more flexible prosodic system that makes it easy to acquire new prosodic patterns. In contrast, the more fixed prosodic system of Alagoans who were adults when migrating can have inhibited them from acquiring Campinas's F0 change rate patterns. However, it is still a question to know why the age of arrival pattern does not apply to females' speech.

Another finding of this study concerns the random effects. The large increase of the variance explained by the models from the marginal to the conditional RZ indicates that individual differences between speakers are important to understanding F0 change rate variability. Actually, in the eight models, the contribution of the random effects to the model's explanatory power surpasses the fixed effects. Since the random effects refer to the particularities of each speaker, they can be related to individual and stylistic factors.

#### V FINAL REMARKS

From the initial hypothesis that the difference between Alagoan migrants and native Campineiros in the F0 change rate parameters would be smaller the younger the migrants when they arrive in Campinas, we found that this hypothesis holds only for males. Mixed-effects regression analyses also revealed that random differences between speakers largely contribute to the explained variance of the statistical models. In the future steps of this study, we will examine other social factors (e.g., speaker's regional identities, social networks) that can potentially explain the gender difference and improve the explanatory power of the models.

## ACKNOWLEDGMENT

Thanks to Livia Oushiro and Natasha Mourão, for the raw data, and Plínio Almeida Barbosa, for a valuable discussion on the fundamental frequency change rates.

## REFERENCES

- [1] Barbosa PA. Conhecendo melhor a prosódia: aspectos teóricos e metodológicos daquilo que molda nossa enunciação. *Revista de Estudos da Linguagem*. 2012;20(1):11–27.
- [2] Barbosa PA. Prosody Descriptor Extractor [Internet]. 2020. Disponível em: <https://github.com/pabarbosa/prosody-scripts>
- [3] Boersma P. Acoustic analysis. In: Podesva R, Sharma D, organizadores. *Research Methods in Linguistics*. Cambridge: Cambridge University Press; 2013. p. 375–96.
- [4] Boersma P, Weenink D. Praat: doing phonetics by computer [Internet]. 2021. Disponível em: <http://www.praat.org/>
- [5] Chambers JK. Dialect acquisition. *Language*. 1992;68(4):673–705.
- [6] Dodsworth R. Migration and dialect contact. *Annual Review of Linguistics*. 2017;3(1):331–46.
- [7] Lenneberg EH. *Biological Foundations of Language*. New York: John Wiley & Sons; 1967. 489 p.
- [8] Mendes RB, Oushiro L. O paulistano no mapa sociolinguístico brasileiro. *ALFA: Revista de Linguística*. 2012;56(3):973–1001.
- [9] Nycz J. Second dialect acquisition: a sociophonetic perspective. *Language and Linguistics Compass*. 2015;9(11):469–82.
- [10] Oliveira MA. *Dialetos em contato: acomodação dialetal por migrantes baianos habitantes da cidade de Bauru, São Paulo*. Araraquara: Universidade Estadual Paulista; 2019.
- [11] Oushiro L. Contrasting age of arrival and length of residence in dialect contact. *Selected Papers from New Ways of Analyzing Variation* 47. 2020;25(2):79–88.
- [12] Santana A de L. *As vogais médias pretônicas na fala de sergipanos em São Paulo [Dissertação de mestrado]*. [São Paulo]: Universidade de São Paulo; 2018.
- [13] Siegel J. *Second Dialect Acquisition*. Cambridge: Cambridge University Press; 2010. 291 p.
- [14] The Language Archive. ELAN [Computer program] [Internet]. Max Planck Institute for Psycholinguistics; 2020. Disponível em: <https://archive.mpi.nl/ta/elan>
- [15] Thomas E. Sociophonetics. In: Chambers J, Schilling N, organizadores. *The Handbook of Language Variation and Change*. Malden: Wiley- Blackwell; 2013. p. 108–27.
- [16] Trudgill P. *Dialects in Contact*. Oxford: Basil Blackwell; 1986. (Language in Society).