



A computational approach for modeling the indexical field

Uma abordagem computacional para a modelagem de campos indexicais

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Abstract: This study investigates how multiple social meanings come to be associated with a linguistic variable. The analyses of listeners' perceptions of tap and retroflex realizations of coda /r/ in São Paulo Portuguese (as in *jornal* 'newspaper' and *bazar* 'bazar'), through an experiment based on the matched-guise technique (LAMBERT *et al.*, 1960; CAMPBELL-KIBLER, 2006, 2009) applied to 185 participants, show that coda /r/ in São Paulo is strongly associated to geographical identities, from which further inferences arise on speakers' social status regarding their social class, area of residence, level of education, along with personal traits such as being "articulate" and "hardworking." Interactions between variable /r/ and participants' social profiles are explored, as well as the fact that certain plausible correlations do not arise, particularly in comparison to previous perception studies. In problematizing the nature of the ideological inter-relations among multiple factual and potential social meanings, an objective and falsifiable computational method for modeling indexical fields is proposed, based on Minimum Spanning Trees (GOWER; ROSS, 1969).

Keywords: indexical fields; social meanings of variation; coda /r/; São Paulo Portuguese; matched-guise technique; computational models of language variation.

Resumo: Este trabalho investiga de que modo múltiplos significados sociais vêm a se associar a uma variável sociolinguística. As análises de percepções de ouvintes sobre as realizações de /r/ em coda como tepe ou retroflexo no português paulistano (como em *jornal* e *bazar*), por meio de um experimento com base na técnica de estímulos pareados (LAMBERT *et al.*, 1960; CAMPBELL-KIBLER, 2006, 2009) aplicado a 185 participantes, mostram que a variável /r/ se associa fortemente a identidades geográficas, a partir das quais surgem inferências sobre o *status* social dos falantes com relação a sua classe social, região de residência, nível educacional, juntamente a

traços pessoais como ser uma pessoa “articulada” ou “trabalhadora”. Exploram-se as interações entre a variável /r/ e os perfis sociais dos participantes, assim como o fato de que certas correlações não se manifestam, particularmente em comparação com outros estudos prévios. Ao problematizar a natureza das inter-relações ideológicas entre múltiplos significados factuais e potenciais, propõe-se um método computacional objetivo e falseável para a modelagem de campos indexicais, com base em Árvores de Distâncias Mínimas (GOWER; ROSS, 1969).

Palavras-chave: campos indexicais; significados sociais da variação; /r/ em coda; português paulistano; técnica de estímulos pareados; modelos computacionais da variação linguística.

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1 Introduction

This study analyzes the social meanings of the tap and retroflex variants of coda /r/ (as in *jornal* ‘newspaper’ and *bazar* ‘bazar’) in São Paulo Portuguese, and how such meanings may have come to be inter-related in an *indexical field*. Following Eckert (2008), it is assumed that

the meanings of variables are not precise or fixed but rather constitute a field of potential meanings – an *indexical field*, or constellation of ideologically related meanings, any one of which can be activated in the situated use of the variable. The field is fluid, and each new activation has the potential to change the field by building on ideological connections. Thus variation constitutes an indexical system that embeds ideology in language and that is in turn part and parcel of the construction of ideology. (ECKERT, 2008, p. 454)

Eckert’s (2008) concept has fostered a more dynamic perspective on the social meanings of language variation and has been fruitfully applied in many different studies to explain ideological inter-relations among the potential meanings of variables (see, e.g., CAMPBELL-KIBLER, 2006, 2009; BECKER, 2013; WALKER *et al.*, 2014; TYLER, 2015; BATTISTI; OLIVEIRA, 2016). The concept has sprung from a criticism to sociolinguistic works that, according to Eckert (2008, 2012), have abandoned the interest in the social meaning of variation

in favor of wider linguistic processes, after Labov's (1963) initial work in Martha's Vineyard. In the development of the field, social meaning has come to be confused with demographic correlations between the usage of variants and speakers' social categories. The present analysis provides further evidence that the relation between variants and social meanings is not direct. Thus, for instance, the fact that men favor the use of a specific variant in a community does not imply that the variant means "masculine."

To build a model of the social meanings of variables, Eckert (2008) elaborates on Silverstein's (2013) concept of *indexical order*. In direct dialogue with Labov's (1972) concepts of *indicators*, *markers*, and *stereotypes*, Silverstein relates 1st-order indices to indicators, geographical or social variables that are not subject to pressures of stylistic variation. Social evaluation on the speakers who use certain variants may come to be associated to the index and be internalized in speakers' dialects to index other elements; according to Silverstein, at this point the variant becomes a marker or a 2nd-order index. The difference between Labov's and Silverstein's conceptualization is that, for the latter, an index is always available to be reinterpreted and to receive new social meanings, a process that takes place in discourse and in context, in a constant reexamination of linguistic forms.

Capturing such emerging meanings has proved to be a challenge and, to the present, there isn't yet a method for computing and reliably replicating indexical fields across studies. Although representations of indexical fields have been rooted in empirical evidence as a rule (see, for instance, the indexical fields for (ING) and /t/ release in Eckert, 2008, p. 466 and p. 469), one can question how speakers go from one meaning to the other, and how these meanings come to be associated to a linguistic variable. This is a matter of *falsifiability*: how to assess the ways in which proposed semantic and ideological relations are established by an individual or group of individuals. A second question is whether an independent researcher would come up with the same representation of the indexical field of a given variable: how can one ensure that the indexical field is not biased by the researchers' own associations of the different potential meanings of a variable? This is a question of *replicability* and *comparability* across studies.

In this study, these questions arise in an analysis of the social meanings of variable /r/ in São Paulo Portuguese. After reviewing results

from production studies that show the variable's main social correlates in the community (section 2), the methods and data are described in detail in section 3: a matched-guise experiment (LAMBERT *et al.*, 1960; CAMPBELL-KIBLER, 2006, 2009) built to assess subjective and unconscious reactions of São Paulo residents to the tap and retroflex variants. The results (section 4) point to the variable's strong correlation with geographical identities, as well as meanings related to speakers' social status. Section 4 also shows that listeners of different social profiles make different associations, and discusses the fact that certain expected correlations do not surface, in comparison to previous perception studies. Finally, a computational method, based on Minimum Spanning Trees (GOWER; ROSS, 1969), is proposed for modeling indexical fields from the same matched-guise data (section 5). It is argued that Minimum Spanning Trees may not only offer a more objective and falsifiable method for plotting visual representations of indexical fields, but also help to predict new potential social meanings of variables (i.e., capturing the "emergent" nature of the social meanings in language variation) and better understand how ideological relations are formed within the field.

2 Coda /r/ in São Paulo

Coda /r/, in words such as *jornal* 'newspaper' and *bazar* 'bazar,' is one of the most salient variables in Brazilian Portuguese (CALLOU *et al.*, 1996; MENDES, 2011; OUSHIRO, 2015) and one of the most studied in Brazilian sociolinguistics (see, e.g., OLIVEIRA, 1983; SKEETE, 1997; CALLOU *et al.*, 1998; GUIOTTI, 2002; BRESCANCINI; MONARETTO, 2008; BRANDÃO, 2009; LEITE, 2010). It can be realized as a trill [r], a tap [ɾ], a retroflex approximant [ɻ], velar fricatives [x ɣ], a uvular fricative [χ], glottal fricatives [h ɦ], and can also be deleted. In the city of São Paulo, home to approximately 11 million people – half of which are internal migrants –, all of these variants can be heard. But in native Paulistanos' speech, apart from deletion (which occurs almost categorically in infinitival verb morpheme, as in *cantar* 'to sing' [kã. 'ta]), the most frequent variants are the tap and the retroflex. The first is normally associated with the state capital city (CRISTÓFARO-SILVA, 2007) whereas the second is a stereotype of the so-called *caipira* dialect, the variety traditionally spoken by rural inhabitants of São Paulo and surrounding states (AMARAL, 1920; HEAD, 1987; BRANDÃO, 2007).

However, a recent study of the variable realization of coda /r/ in the city of São Paulo (OUSHIRO, 2015) shows that the retroflex variant is not infrequent among native Paulistanos. In a sample of 118 one-hour-long sociolinguistic interviews, with speakers balanced for sex/gender, three age groups (20-34 y.o.; 35-59 y.o.; 60+ y.o.), two levels of education (up to high school; college), and two areas of residence (central area; peripheral area), retroflex /r/ accounted for 28.3% of pronounced tokens of coda /r/ (N = 9,226).

The interview schedule included questions that aimed at collecting speakers' overt reactions and metapragmatic discourse on both retroflex and tap /r/. Thus, in the last part of the interview, participants were asked: "What do you think of this manner of speaking, *a porta tá aberta*" ('the door is open'), for which interviewers were instructed to pronounce the words *porta* and *aberta* with clear and exaggerated retroflex /r/ (see MENDES; OUSHIRO, 2012). Participants were also asked who speaks in this manner and whether they themselves speak that way. A content analysis of participants' answers to these questions was systematized in a word cloud (FIGURE 1), which visually represents the most frequent terms employed by the participants (the larger the font, the more frequently the term occurred).

FIGURE 1 – Word cloud of terms associated with the sentence *A porta tá aberta* 'the door is open,' realized with retroflex coda /r/



Source: Oushiro (2015, p. 98)

Figure 1 makes it clear that the main idea associated with the retroflex variant is *interior* ‘countryside.’ The notion is also elaborated in more specific definitions such as *interior de São Paulo* ‘São Paulo’s countryside,’ *mineiro* (natives from the state of Minas Gerais, north of the state of São Paulo), and certain specific cities in the state (*São Bernardo, Campinas, Sorocaba*). The great majority of speakers commented overtly on the realization of /r/ to explain their answer. This manner of speaking was often referred to as a *sotaque* ‘accent,’ and very few participants recognized it as something a Paulistano (and themselves) would say.

In contrast, Figure 2 shows participants’ metapragmatic comments on the exact same sentence (“What do you think of this manner of speaking: *a porta tá aberta*”) in which, instead, the two tokens of coda /r/ were realized by the interviewer as taps. This question was made right after the previous questions in order to provoke a direct contrast and, in fact, most participants did characterize it as a “Paulistano” manner of speaking – the most frequent term they used. Notice, however, that the second and third most frequent comments were, respectively: (i) on the verb *estar* ‘to be’ – i.e., participants did not comment on coda /r/ realization but, instead, commented on the fact that the verb was reduced from *está* to *tá*, which implicitly signals that the tap realization of coda /r/ is not worth commenting in this case; and (ii) a characterization of such manner of speaking as *normal* – which can be similarly interpreted as a statement that there was nothing unusual to comment about, and also that this realization is the community’s *norm*.

FIGURE 2 – Word cloud of terms associated with the sentence *A porta tá aberta* ‘the door is open,’ realized with tap coda /r/



Source: Oushiro (2015, p. 101).

Multivariate mixed-effects logistic regressions on the production data, performed in R (R CORE TEAM, 2014, 2018), included social and linguistic predictors¹ as fixed effects, and Speaker and Lexical Item as random effects. In addition to showing that retroflex /r/ is not infrequent in native Paulistanos’ Portuguese – contrary to most Paulistanos’ discourse on the variable –, occurring in nearly a third of all tokens of pronounced coda /r/, the results for social predictors showed that the main effects were speakers’ social class, area of residence, mobility, level of education, and sex/gender. The retroflex variant was favored by working class speakers, living in peripheral areas, of low mobility (those who have always lived in the same neighborhood), lower levels of education and males – all expected correlations for stereotype variables. Although age group was not a significant predictor, an interaction between age group and social class/area of residence showed that there is a change in progress towards the retroflex in working-class peripheral areas and, in the opposite direction, a change in progress towards the tap in more affluent central areas. This raises the question of whether retroflex /r/

¹ The linguistic predictors were Preceding and Following Phonological Context, Syllable Stress, Position of coda /r/ in the word, and Morphological Class. See Oushiro (2015, chapter 5) for a full account of these results.

has different social meanings for different social groups, what these social meanings are, and how they come to be associated with different variants. From speakers' overt evaluations, tap and retroflex /r/ are mainly – and practically only – associated with geographical identities. Thus, a matched-guise experiment was applied to investigate speakers' subjective and unconscious judgments on variable /r/.

3 Experimental design

The experiment design follows Campbell-Kibler's methods for analyzing variable (ING) in English (2006, 2009). First, four native Paulistanos were recorded in sociolinguistic interviews – two men and two women, all of whom were around their early 30s, had a college degree and lived in the West Zone of São Paulo. Their social characteristics were controlled in order to minimize the effect of other variables beyond coda /r/. The option for naturally-occurring conversations instead of readings follows from the observation that this type of recording has the advantage of creating richer and more realistic impressions on the listeners, who perceive the speakers as real people with their own history and personality (CAMPBELL-KIBLER, 2006).

From these recordings, four short excerpts were selected, one from each speaker, and each containing 4-7 tokens of coda /r/. The speakers were contacted again to record controlled productions of coda /r/ as taps and retroflexes. The original recordings were then digitally manipulated in Praat (BOERSMA; WEENINK, 2004) to produce 8 stimuli, one pair for each speaker identical in all respects except for the realization of coda /r/, either as taps or retroflexes, extracted from the controlled recordings. In excerpts (1)-(4), tokens of manipulated coda /r/ are shown in bold.²

- (1) Speaker 1 (M): mas aí você tem aqueles outros aspectos meio meio...
bizarros né que nem a questão do **passaporte interno**... ahn...
(Interviewer: ahn) se você é do **interior**... (vo)cê não pode i(r) pra
capital... sem a **ordem** do **governo**... (Interviewer: ahn) se você não
tive(r)... eh (vo)cê ainda- é/ o que que o pessoal faz? eles pula(m) a
fronteira faz(em) que nem no México

² Tokens of deletion, all of which occurred in the infinitive morpheme, were not considered.

‘but then you have all those other sort of... bizarre aspects right, such as the internal passport matter... uhn... (Interviewer: aham) if you’re from the countryside... you can’t go to the capital city... without a government’s permit... (Interviewer: aham) if you don’t have one... uhn you still can- uh what do people do? they cross the border just like in Mexico’

- (2) Speaker 2 (F): e brincava muito assim de **Barbie** sabe? e brincava muito sozinha também mesmo quando eu não tinha as amiguinhas eu brincava... (Interviewer: (vo)cê não tem irmãos?) sozinha... tenho uma **irmã** mais nova cinco anos... então nessa época da infância não dava pra brinca(r) né com ela era muito diferente... **porque** assim (de/)... na adolescência até quando ela tinha vai quinze eu tinha vinte até dava pra **conversa(r)** e tal hoje em dia dá pra... sai(r) com ela **normalmente**...

‘and I used to play a lot with Barbie y’know, and I’d play a lot by myself too, even when I didn’t have my little friends I played... (Interviewer: don’t you have siblings?) by myself... I have a younger sister, five years younger than me... so at this time in childhood I couldn’t play with her ‘cause it was too different... like when we were teenagers, when she was fifteen and I was twenty, we could talk and such, like nowadays... we can normally hang out...’

- (3) Speaker 3 (M): O BG era meio que um... **quartel** de elite... né... a gente tinha muito acampamento... e a gente tinha horas e horas todo dia de **ordem** unida... (Interviewer: ahn) **ordem** unida é **marcha(r)**... **esquerda** volve(r) direita **volver**... (Interviewer: uhum) (né) eu odiava... eu odiava... com toda minha **força**

‘BG was sort of an elite quarter y’know... we had a lot of camping... and we had hours and hours of drill commands every day... (Interviewer: uhn) drill command is marching... left turn right turn... (Interviewer: uhum) I hated it... I hated it... from the bottom of my heart’

- (4) Speaker (F): ah a gente tinha... **diversas** atividades né... tipo... coleta de **jornal**... eh entrega pra reciclagem... eh **organização** de **bazar**... e ah e tinha os... os acampamentos né... que era bem legal assim

‘we had... tones of activities right... like... collecting newspapers... ahm delivering them for recycling... ahm organizing bazars... and ahm there was the camping trips right... which were like very cool’

The eight stimuli were separated into two groups, each with one stimulus per speaker, according to the distribution in Table 1. Henceforth, reference to each stimulus will be made by the identification of the speaker and the variant (e.g. “1.t,” “3.r” etc.).

TABLE 1 – Distribution of stimuli in two groups

	Group A	Group B
Speaker 1 (M)	tap (1.t)	retroflex (1.r)
Speaker 2 (F)	retroflex (2.r)	tap (2.t)
Speaker 3 (M)	retroflex (3.r)	tap (3.t)
Speaker 4 (F)	tap (4.t)	retroflex (4.r)

Next the stimuli were played for a number of volunteers, who were asked to listen to the recordings and, as they were doing so, to imagine and to describe what they thought the speaker was like, in terms of social and personal characteristics. Some examples of such listeners’ impressions are given in (5)-(9).

- (5) José: ele [1.t] parece que (es)tá dando uma aula... eu imagino assim um um professor universitário tipo- alguém dando uma palestra...

‘he [1.t] sounds like he’s teaching a class... like I imagine a- a professor like- someone giving a lecture...’

- (6) Antônio: meu muito ‘paty’ essa mina! [2.t] [risos] a patricinha de Higienópolis! (Interviewer: [risos] ah é? por que você acha...?) ah tipo ela brin-/ brincava de Barbie... não tinha amigos... parece aquelas menininha meio riquinha... fresquinha...

‘bro this chick [2.t] is very *paty*!³ [laughs] the *patricinha* from Higienópolis!⁴ (Interviewer: [laughs] oh yea? why do you think...?) well like she pla- played with Barbies... didn’t have any friends... sounds like those rich spoiled girls...’

³ *Paty* and *patricinha* roughly refer to a “rich, upper class girl.” See a more detailed definition ahead.

⁴ Upper class neighborhood in São Paulo.

- (7) Joana: [risos] eu acho ela... [2.r] *maloqueira*... *maloqueirona* assim... não sei... eu acho que ela é da zona leste... bem... bem suburbana...
 ‘[laughs] I find her... [2.r] *maloqueira*... *maloqueirona*⁵ like... I don’t know... I think she lives in the East Zone... (she’s) very... very suburban’
- (8) Marcos: ele [3.t] deve se(r) um negão tipo armário!... três por quatro!... [risos] mas não sei onde ele mora... po- poderia se(r) qualquer lugar de São Paulo
 ‘he [3.t] must be a huge black dude!... huge!... [laughs] but I don’t know where he might live... it- it could be anywhere in São Paulo’
- (9) Mariana: ela [4.r] é uma pessoa tímida mais recatada... diferente da outra... [2.t] deve ter crescido em apartamento... ou... não sei ela pode ser do interior
 ‘she [4.r] sounds more shy more coy... different from the other one... [2.t] she must have grown up in an apartment... or... I don’t know she may have come from the countryside’

Participants had little difficulty imagining a situation in which each of the speech events could have taken place and attributing social characteristics to the speakers. Although participants avoided making categorical statements about the speakers (which can be seen from the extensive use of expressions such as “I think,” “must,” “may,” “I don’t know”...), these are quite rich descriptions of very short speech excerpts: “professor giving a lecture,” “*patricinha*,” “resident of Higienópolis,” “rich little girl,” “spoiled,” “*maloqueirona*,” “East Zone,” “suburban,” “huge black dude,” “shy,” “coy,” “grew up in an apartment,” “countryside.”

After listening to four stimuli, either from group A or B (see TABLE 1), in this phase of the experiment participants also listened to the corresponding alternative guise, to verify what kinds of contrasts would come up. When listening to a pair, most participants explicitly mentioned the different realizations of coda /r/, further confirming that it is a stereotype in the community.

⁵ Originally, individuals living in *malocas*, precarious habitations in favelas. The term now means low class trouble-makers, but it is also associated with supporters of a specific soccer team (and, as such, it is not necessarily negative).

The most frequent terms used to describe the speakers were organized in the following questionnaire, intended for quantifying and systematically analyzing the responses. It includes ten 5-point semantic differential scales (10), three categorical variables (11), and 30 checkboxes of personal traits (12). For the latter, participants could check as many boxes as they considered pertinent to a particular speaker.

(10) Semantic differential scales
 For you, this person seems...
 (Choose one option on each line)

	Little/few					Very/many
Extroverted		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Educated		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Masculine ⁶		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Intelligent		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Formal		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Friendly		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Paulistano		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
To have an accent		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
To have friends		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

This person must live in a...
 (Choose one option)

More peripheral area More central area

(11) Qualitative variables
 In which zone of the city does this person probably live?

- North
- South
- East
- West
- Downtown
- I don't know

⁶ Or “Feminine,” for female voices.

In which age group do you think this person is?

- Teenage years
- In his/her 20s
- In his/her 30s
- In his/her 40s

Which social class do you think this person is?

- Low class
- Low-middle class
- Middle class
- Upper-middle class
- Upper class

(12) Checkboxes

From what you heard, you think this person must be...

(Check as many boxes as you want)

- | | | |
|--|--------------------------------------|---|
| <input type="checkbox"/> tall | <input type="checkbox"/> trustworthy | <input type="checkbox"/> sincere |
| <input type="checkbox"/> white | <input type="checkbox"/> simple | <input type="checkbox"/> gay/lesbian |
| <input type="checkbox"/> shy | <input type="checkbox"/> hardworking | <input type="checkbox"/> spoiled |
| <input type="checkbox"/> cool | <input type="checkbox"/> confident | <input type="checkbox"/> conservative |
| <input type="checkbox"/> pothead | <input type="checkbox"/> solidary | <input type="checkbox"/> <i>caipira</i> |
| <input type="checkbox"/> religious | <input type="checkbox"/> practical | <input type="checkbox"/> depressed |
| <input type="checkbox"/> close to Family | <input type="checkbox"/> lazy | <input type="checkbox"/> nerd |
| <input type="checkbox"/> articulate | <input type="checkbox"/> impolite | <input type="checkbox"/> sophisticated |
| <input type="checkbox"/> annoying | <input type="checkbox"/> funny | <input type="checkbox"/> independente |
| <input type="checkbox"/> snobbish | <input type="checkbox"/> laidback | <input type="checkbox"/> <i>patricinha/mauricinho</i> |

Two italicized terms, *caipira* and *patricinha/mauricinho*, have not been translated from Portuguese, to avoid the risk of cultural mismatches. Roughly, *caipira* has originally referred to rural inhabitants and to their culture, especially from the state of São Paulo; currently, the term may be extended to all natives of the state, even in urban areas, but it may also carry the meaning of illiterate working-class peasants, or someone not used to the ways of the big city. *Patricinha* (or *paty*) generally refers to

upper-middle and upper-class girls who are especially concerned about fashion and looks; their male correlate is a *mauricinho*. These terms are in principle negative stereotypes, but it is possible to find online websites that will use them positively, in favor of certain lifestyles.

At the end of the questionnaire, participants also had the option to make comments and to describe other impressions they had about the speakers. Lastly, they were asked to provide some sociodemographic data: sex, age, occupation, neighborhood, place of birth, and length of residence in São Paulo (if not a native to the city).

The above list of variables can be classified into three types of social meanings possibly associated with variable /r/ (TABLE 2). Paulistinity, accent, area of residence, and city zone refer to geographical identities. From Oushiro's (2015) production analyses, the initial expectation was that speakers in retroflex-guise would be perceived as less Paulistano, as having a thicker accent,⁷ and as residents of more peripheral areas.

⁷ The notion of “accentedness” is certainly controversial. Many Paulistanos will not hesitate to say that their speech variety is the one that is closest to “standard Portuguese,” heard on the national TV and radio news broadcast, or simply that they “don’t have an accent.” Many others, however, regard Paulistano Portuguese as a variety just like any other, and for them Paulistanos “have an accent.” The comment of an online respondent illustrates the matter: “The question about the person having an accent is weird, to say the least. I answered it, but I don’t know if it should count. I have a Paulistano accent. Some speakers sounded like they had a countryside accent. We all have accents.” (participant 37, female, 54 years old, from São Paulo). Unfortunately, it is not possible to know each participant’s opinion on the matter, as this is not something that was actively surveyed. However, this fact does not invalidate the analyses. One of the interests is to contrast the perceptions of different groups of listeners. If the notion of “accentedness” is indeed as fluid and relative, the expected result is that mean ratings for accent will be virtually identical for tap and retroflex /r/ for all groups. If, on the contrary, there are significant differences among groups, the analysis will signal which groups find Paulistanos to have an accent and which groups don’t.

TABLE 2 – Classification of variables according to types of social meanings

	Geographical identity	Status	Solidarity/ Dynamism
Scale variables	Paulistanity Accent Area of residence	(Area of residence) Formality Education Intelligence	Friendliness Having friends Extroversion Femininity Masculinity
Qualitative variables	City zone	Social class	Age group
Checkboxes	<i>caipira</i>	(<i>caipira</i>) tall white articulate snobbish confident practical conservative sophisticated independent simple <i>patricinha/ mauricinho</i>	shy cool religious close to family trustworthy solidary lazy funny laidback sincere

City zone was included because two of the five city zones were frequently mentioned in the open interviews: the East Zone, normally associated with working-class speakers, and the West Zone, reversely associated with middle and upper classes. Area of residence can also be considered a status variable, since living in more central or more peripheral areas in São Paulo is closely related to people’s social class. Other variables regarding status are education, formality, and intelligence. Since the production analyses showed that the retroflex is favored by less educated and working-class speakers, the present analysis aims to verify if these correlations are reproduced in people’s perceptions and whether the symbolic value of education and social class extend to meanings related to formality and speakers’ intelligence.

Previous studies on social perceptions and attitudes (LAMBERT *et al.*, 1960; BOURHIS; GILES, 1976; GILES; BILLINGS, 2004) have generally shown that variants associated with less privileged social groups tend to be more positively evaluated in traits of social solidarity and dynamism;⁸ hence, for the variables in the third group, it is expected that speakers will be perceived as having more friends, and as being friendlier, more extroverted and younger when listened to in their retroflex-guise. The dimensions of femininity/masculinity are based on the correlation for the production study: since retroflex /r/ is favored by males, will speakers be perceived as more masculine-sounding (or as less feminine-sounding) when using this variant?

Finally, not all characteristics in the checkbox list fit perfectly into one of the three categories, but one can consider “caipira” a type of geographical identity (and, possibly, also related to status); attributes such as “tall,” “white,” “confident,” “sophisticated,” and “patricinha/mauricinho” as being related to status; and traits such as “religious,” “close to family,” “trustworthy,” and “cool” as related to solidarity/dynamism.

The questionnaire was applied to 185 participants who live in the city of São Paulo; 84 of them were recruited in face-to-face interactions and 101 through online social media, which directed participants to a Qualtrics webpage.⁹ Similarly to the “open interview” phase, participants

⁸ Although some studies show that certain accents, such as Birmingham English, tend to be negatively evaluated in all dimensions (see, e.g., GILES, 1970; HIRAGA, 2005).

⁹ The main researcher was assisted by a colleague in this task. To test for the possible interference of experimental condition (main researcher, colleague, Qualtrics) in participants' responses, chi-square tests and anovas were run, followed by Tukey post-hoc tests for multiple comparisons (see NIEDZIELSKI, 1999; HAY; DRAGER, 2010; CAMPBELL-KIBLER, 2010 for detailed discussions on the effect of experimental conditions). There were no significant differences between my colleague and me, but interestingly there were a few significant differences for two semantic differential scales when comparing face-to-face and Internet responses: (i) level of education (Qualtrics vs. researcher: $p < 0.001$; Qualtrics vs. colleague: $p < 0.01$); and (ii) friends (Qualtrics vs. researcher: $p < 0.01$; Qualtrics vs. colleague: $p < 0.001$). For both variables, differences between ratings for tap and retroflex /r/ were greater in the online condition, signaling that participants were somewhat more “neutral” when in presence of a researcher and more “judgmental” in their absence. This has implications for future studies, but this discussion is beyond the scope of the present article.

were asked to listen to each excerpt and imagine what each speaker was like, but, differently from the previous phase, they only listened to each speaker once (the stimuli in either group A or group B from Table 1); they could listen to each recording as many times as desired, but (as could be observed in the face-to-face data collection) few speakers did listen to each stimulus more than once. On average, it took participants 15 minutes to listen to four excerpts and fill out a questionnaire for each speaker.

Participants’ demographic characteristics are summarized in Table 3. The sample is balanced for sex (97 women and 88 men), area of residence (94 living in central areas and 91 in peripheral areas), and to a lesser degree for place of origin (129 native Paulistanos and 56 from other places). It is quite unbalanced regarding age (145 between 18-34 years old) and level of education (178 in college or with a college degree), thus these two variables were excluded from further analyses.

TABLE 3 – Distribution of participants according to their social characteristics

		Females (N = 97)			Males (N = 88)			N
		18-34 y.o.	35-59 y.o.	60+ y.o.	18-34 y.o.	35-59 y.o.	60+ y.o.	
Central (N = 94)	High school	1	0	0	0	0	0	1
	College	24	20	0	42	6	1	93
Peripheral (N = 91)	High School	0	0	1	4	1	0	6
	College	43	7	1	31	3	0	85
N		68	27	2	77	10	1	185

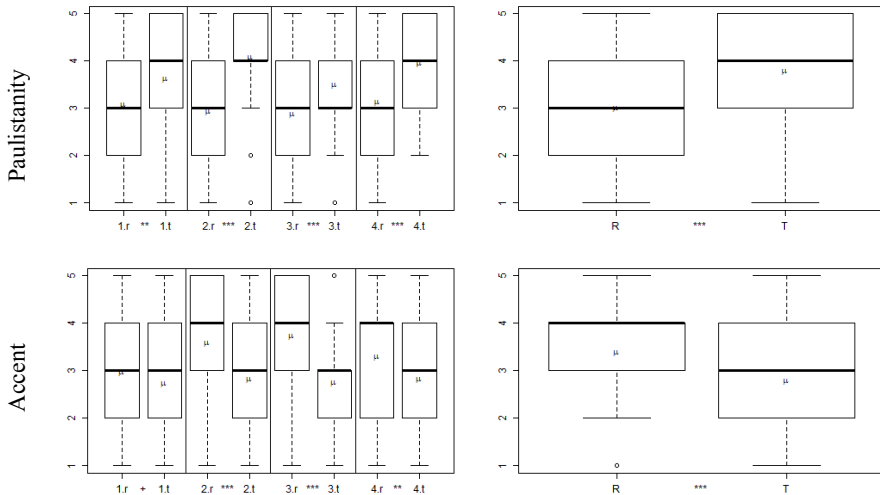
Statistical analyses on the 740 data points (185 participants x 4 speakers) were performed in R (R CORE TEAM, 2018). Quantitative variables (semantic differential scales) were analyzed in Wilcoxon tests (a non-parametric version of the t-test) and in mixed-effects linear models that tested for interactions between predictor variables; qualitative variables were analyzed in chi-square tests; and the checkboxes in chi-square and mixed-effects logistic regression models. The computational models for building indexical fields will be described in detail in section 5.

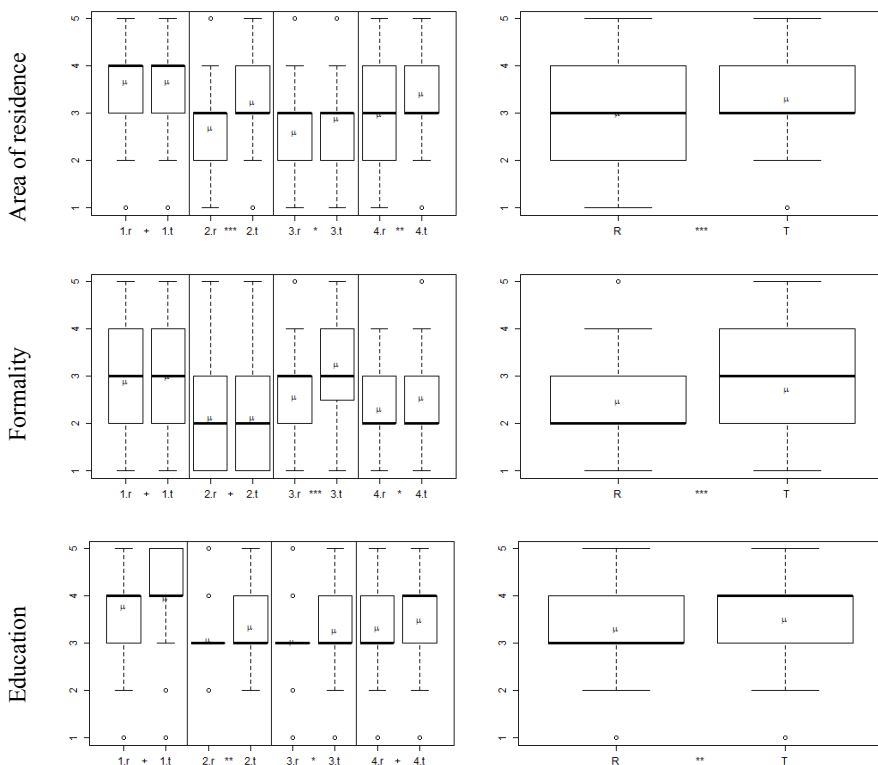
4 Social meanings of coda /r/

4.1 Scalar variables

This section analyzes listeners' responses to the semantic differential scales (how extroverted, educated, intelligent etc. the speakers sounded) according to guise and speaker. From the 10 scales, only Paulistinity, accent, area of residence, formality, and education exhibited significant correlations with variable /r/. Figure 3 summarizes participants' responses in boxplots, showing their distribution and dispersion in the five-point scales. Between each pair of variants (by speaker, on the left, and for the general sample, on the right), significance levels for one-tailed Wilcoxon tests corrected by the Bonferroni method are indicated according to the convention: $+p > 0.05$; $*p < 0.05$; $**p < 0.01$; $***p < 0.001$. The mean value for each distribution is signaled by "μ." The scales are shown according to the difference in mean value for tap and retroflex /r/, i.e., the biggest difference is found for the Paulistinity scale, followed by accent, area of residence etc.

FIGURE 3 – Scalar variables significantly correlated with variable /r/





The three main scales showing significant differences in participants' perception relate to geographical identities, indicating that the main social meaning of the variants is the opposition Paulistano vs. non-Paulistano, or prototypical vs. non-prototypical Paulistano. It is worth noting that in the Paulistanity and area of residence scales, judgments concentrate in the middle point 3 (the median represented by the bold horizontal line) for retroflex /r/, which shows a certain tendency for neutral responses (seen globally); in the accent scales, this occurs for the tap-guises. The dispersion of responses shows that there is less consensus on how Paulistano the retroflex sounds, how accented is the tap and the area of residence of retroflex users. For instance, in the accent scale, note that tap stimuli were judged both with low (1 and 2) and with high (4 and 5) degrees of markedness, in equal proportions, which reflects the divergence in opinions as to whether Paulistanos have an accent. On the other hand, the community is more consensual on the

Paulistinity of the tap, on how accented the retroflex sounds, and that the tap is associated with more central areas, as seen by the concentration of responses above the middle point on these scales.

In addition to a geographical identity, the correlation with area of residence can also be interpreted as a status differentiation between the variants. Since the upper class in São Paulo is concentrated in more central areas in the city, the association between the tap and these speakers also reflect an association with social class. The correlations with formality and education also support this interpretation. Relatively to the tap-guise, speakers were perceived as less formal and as less educated when listened to in their retroflex-guise.

However, correlations with these five scales are not uniformly reproduced for all speakers (figures on the left). The Paulistinity scale is the only one for which there are significant differences for all speakers: all are perceived as significantly more Paulistano-sounding in their tap-guises. In the other cases, the global correlations have greater contribution from specific speakers, whereas perceptions on others are not affected by the variants. Speaker 1, in particular, seems to be especially immune to the impact of the tap or the retroflex. Two facts may account for this result: (i) since stimuli order was not randomized, his recording was always the first to be listened, which possibly turned him into a baseline against which other stimuli were judged; (ii) speaker 1's excerpt is the only one in the third person, describing the use of an "internal passport," whereas the other three speakers are presented narrating personal past experiences (see excerpts in (1)-(4) above); the third-person narrative may have contributed to the impression of a more distanced and impersonal speech event. In that regard, recall a participant's comment in (5), in which this speaker is perceived as a professor; this frame has the potential to keep him from receiving attributions of personal characteristics such as thickness of accent and area of residence.¹⁰

¹⁰ It is also curious that speaker 1 is the only one who employs a stigmatized variant at the end of the excerpt, namely absence of subject-verb agreement: *o que que o pessoal faz? eles pula(m) a fronteira faz(em) que nem no México* (lit. 'they crosses the border, does like in Mexico'). This doesn't affect listeners' judgments on his level of education, in average higher than for all the other speakers. It is possible that speaker 1, being initially perceived as a more educated, resident of a central neighborhood etc., becomes "immune" to the effects of nonstandard subject-verb agreement (see also CAMPBELL-KIBLER, 2006, 2009 on the "bullet-proof effect").

Even though not all scales exhibit significant correlations for all speakers, for each pair of stimuli, the relation between retroflex and tap /r/ has a definite directionality: for example, in the accent scale, no speaker is judged as having “less accent” when listened to in the retroflex-guise.

On the other hand, differently from the initial hypotheses, speakers were not perceived as having more friends, as being friendlier, more extroverted, less intelligent and less feminine (in the case of female speakers) or more masculine (in the case of male speakers) when listened to in their retroflex-guise.¹¹ Mendes (2016), in a study about perceptions on nominal number agreement, did not observe differences in the friendliness scale either but, differently from this study, observed significant correlations for effeminacy and intelligence according to the use of the standard or nonstandard variant. The sexuality dimension can probably be accounted for due to the fact that, in Mendes’s study, all speakers were males and the scale measured how “effeminate” they sounded. The intelligence scale, however, can be more directly compared; differently from nominal agreement, although the realizations of coda /r/ also correlate with percepts of education, these don’t extend to judgments of the speakers’ degree of intelligence. This is evidence that two variables that have similar social stratification in terms of speakers’ production (both the retroflex and nonstandard nominal agreement are favored by males, less educated and working-class speakers) do not necessarily have the same set of correlations in terms of perceptions. The relation between language uses and sociolinguistic perceptions is an indirect one. This point will be further explored ahead, in section 4.3.

Analyses so far have reported the perceptions of the community, not considering participants’ social profile. To analyze whether female and male listeners, residents of central and peripheral areas, and from different places of origins differently perceive tap and retroflex, multivariate linear regression models including the interaction between guise and listeners’ sex, area of residence and place of origin were performed in the data.¹² In particular, in knowing the strong correlation between variable /r/ and

¹¹ The statistical analyses for these two scales were performed separately for male and female speakers, since the hypotheses predicted opposite directions for speakers 1 and 3, on the one hand, and 2 and 4 on the other.

¹² R lmer formula: scale ~ variant * sex + variant * region + variant * origin + (1|speaker) + (1|participant).

speakers’ area of residence in the production study, the interest here is too check whether residents of more peripheral areas, who favor retroflex /ɾ/, have different perceptions of its social meanings than residents of more central areas.

For most scales, interactions were not significant, which means that perceptions were not substantially different according to the participants’ social characteristics. However, two scales showed significant interactions: (i) Paulistanity, for which variant interacts with listener’s area of residence and place of origin, and (ii) accent, for which variant interacts with area of residence. These interactions are shown in Figures 4 and 5.

FIGURE 4 – Difference in mean ratings for Paulistanity (R – T) according to participants’ area of residence (above) and Place of origin (below)

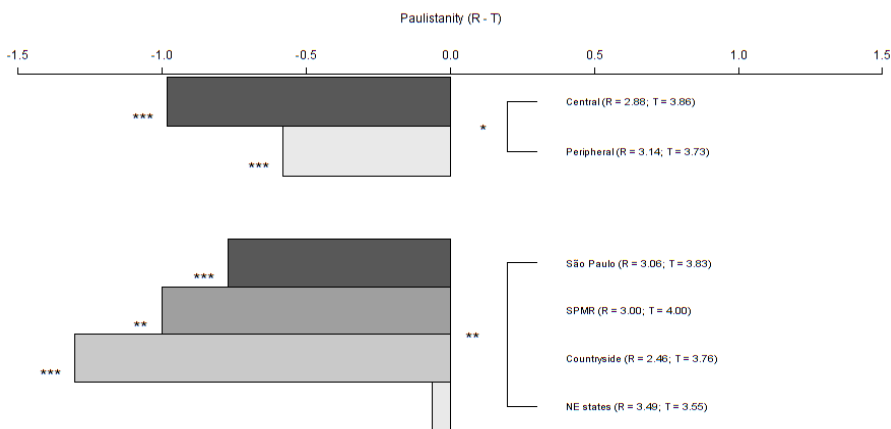
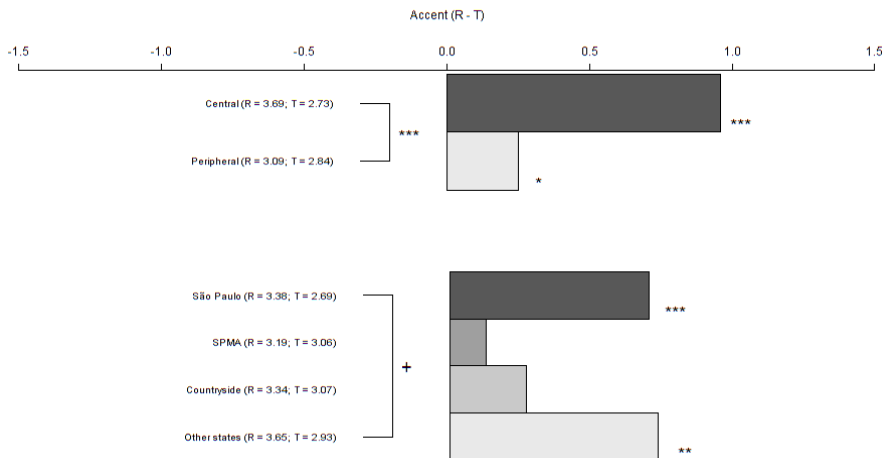


FIGURE 5 – Difference in mean ratings for Accent (R – T) according to participants’ area of residence (above) and Place of origin (below)



The interactions indicate that individuals residing in different areas of the city (more central or more peripheral areas) and from different places of origin (São Paulo, SP Metropolitan Region,¹³ state interior or other states) differently perceive retroflexes and taps regarding their degree of Paulistanity and accent.

Figure 4 shows the interactions in the Paulistanity scale. The horizontal bars represent the difference in mean ratings for retroflex- and tap-guises ($\mu R - \mu T$), for speakers living in different areas (top) and from different origins (bottom). The figure also shows the mean ratings for each variant. In all cases, the subtraction results in a negative value, indicating that retroflex /r/ was perceived as sounding less Paulistano than the tap for all groups ($R < T$), similarly to the global analyses. The interactions consist of the fact that such differences are greater for residents of central areas and participants who are native Paulistanos, native metropolitans or from the state of São Paulo. For residents of more peripheral areas, the difference is also significant, but it was smaller than

¹³ The SPMR comprises 39 cities in a large conurbation of 20 million inhabitants. In this category were classified participants who were born in those cities, except for the state capital São Paulo.

for central dwellers; for participants from other states, tap and retroflex /r/ sound equally “Paulistano.”

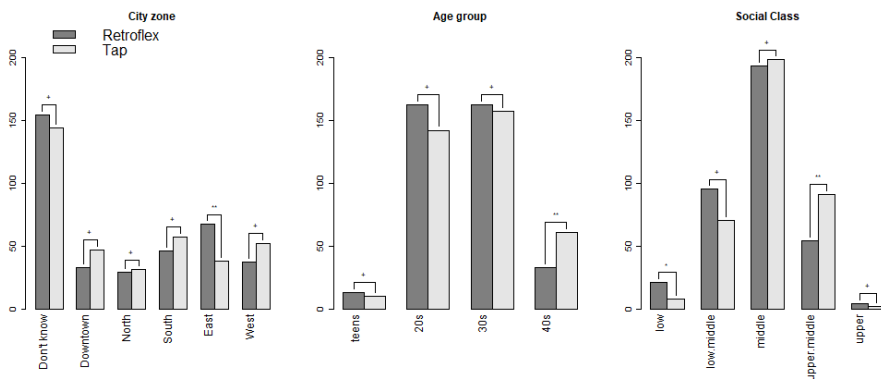
The production analysis in Oushiro (2015) had shown that variable /r/ strongly correlates with speakers’ area of residence, especially among the youth (and recall that most of the present sample is composed of younger participants). Figure 4 shows that the distinction Paulistano vs. non-Paulistano is more properly made by residents of central areas, who perceive retroflex /r/ as non-native; residents of peripheral areas, although also showing the same trend direction, are somewhat more “tolerant” to the Paulistanity of retroflex /r/. Difference between these two groups is significant to a 5% α -level ($p = 0.02$). As for place of origin, Figure 4 shows that those born in the capital city São Paulo, in the SP Metropolitan area or the interior significantly differentiate tap and retroflex /r/ in their degree of Paulistanity, especially the latter group. These participants are the ones who are frequently recognized in São Paulo as non-natives because of their realization of coda /r/, and thus are the ones who differentiate the variants’ geographical meaning more markedly – even more than native Paulistanos. On the other hand, listeners who have migrated from other states don’t differentiate taps and retroflexes in their degree of Paulistanity. The great majority of these out-of-state migrants have come from Brazil’s Northeast, an area of predominant fricative /r/ ([x ʎ χ h ã]) and, more importantly, no taps or retroflexes. The mean ratings for them were 3.49 for the retroflex and 3.55 for the tap, both above the middle “neutral” point, signaling that for these listeners, retroflex /r/ sounds just as Paulistano as the tap.

Listeners’ area of residence also interacts with variants of /r/ in relation to percepts of accent (FIGURE 5). In this case, the subtraction $\mu_R - \mu_T$ results in positive values, which means that retroflex /r/ is judged by all groups as a thicker accent than the tap ($R > T$). Nevertheless, residents of central areas consider the retroflex variant as a much more marked accent than the tap, and significantly more than residents of more peripheral areas ($p < 0.001$). Thus, although the direction of correlations is not different between central and peripheral residents, the degree to which they consider retroflex /r/ less Paulistano and more accented provides evidence of how tap and retroflex are perceived and may explain the opposite directions of language change in speakers’ production, as seen in section 2.

4.2 Qualitative variables

The qualitative variables refer to the attribution of a city zone, age group, and social class to the speakers. These variables were analyzed in chi-square tests. The response distribution can be seen in Figure 6.

FIGURE 6 – Attribution of zone, age group and social class according to guise



For city zone, one can notice that most listeners were not able to attribute a specific zone of residence to the speakers, as most of them selected “I don’t know” both for tap and retroflex-guises.¹⁴ Although listeners associated /r/ variants with central or peripheral areas, the same can’t be said about the five zones. The only significant difference is found for the East Zone: speakers listened to in their retroflex-guise were more frequently attributed this zone of residence than when they were in tap-guise ($p = 0.005$). The general response distribution for this variable has a low probability of being observed in case the null hypothesis is true ($\chi^2 = 14.55(5)$, $p = 0.01$).¹⁵

For age group, there is a high concentration of responses in factors “in their 20s” and “in their 30s,” which is likely a result from speakers’ true age (they all are around their 30s, and do sound like that group).

¹⁴ This option was included only for city zone because, just as a number of participants of the open interview phase mentioned the East and the West Zones, many others stated that it’s impossible to know in which zone a person lives in São Paulo.

¹⁵ Since the analyses of qualitative variables and checkboxes in this and in the following section refer to 33 different chi-square tests, one might prefer to adopt an α -level of $0.05 / 33 = 0.0015$ in reading and interpreting these data.

Here too there are no significant differences according to which variant was listened to, except for “in their 40s” ($p = 0.004$): there was a slight tendency for speakers to be attributed this trait in their tap- rather than in their retroflex-guise. Similarly to city zone, overall distribution of responses is not random ($\chi^2 = 10.13(3)$, $p = 0.02$).

The perception of social class also showed significant correlations ($\chi^2 = 19.78(4)$, $p < 0.001$). Although it was rare for speakers in this sample to be perceived as “low class,” this occurred more frequently when they were listened to in their retroflex- rather than in their tap-guises ($p = 0.02$); conversely, the attribution of “upper middle class” happened significantly more frequently in tap than in retroflex stimuli ($p = 0.002$). Differences in “lower middle class” and “middle class,” although not significant, seem to follow the overall association between retroflex-lower classes and tap-upper classes.

Thus, the nominal variables also point to the importance of the geographical and status dimensions for variable /r/, although in somewhat weaker correlations. A new dimension, relative to speakers’ dynamism, is suggested by the correlation with speakers’ age, as the tap is associated with older speakers. However, the fact that the converse relation “retroflex-younger speakers” is not observed and that most responses concentrate on the intermediary levels, whose differences are not significant, indicate that perceptions of age is more dependent on the speakers’ individual voice traits than any effective intervention of variable /r/.

4.3 Checkboxes

Let us now turn to the analysis of the personal characteristics’ list (being tall, white, articulate, snobbish, shy etc.). The aim here is to determine whether the attribution of a specific personal trait is due to impressions on an individual speaker or whether it is possible to infer an effect of variable coda /r/. Just as in the previous analyses, the expectation is that impressions evoked by specific speakers or by the speech content be neutralized when selected for tap and retroflex /r/ in similar proportions; if, differently, there is an effect of the variant itself, these should be reflected in significantly different rates of selection.

Each characteristic was initially analyzed in chi-square tests to determine the frequency it was selected for each variant. Out of the 30 checkboxes, only 5 are significantly correlated with coda /r/: *caipira*,

simple, hardworking, articulate, and sophisticated.¹⁶ The first three are favored by retroflex /r/ and the last two by the tap. Table 4 shows the frequency and the proportions these characteristics were selected (✓) when speakers were listened to in each guise, as well as the result for the chi-square tests. The shaded cells highlight the variant favoring the box selection.

TABLE 4 – Traits correlated with variable /r/

Trait	R	%R	T	%T	Total N	χ^2	p
<i>Caipira</i>							
x	329	48	362	52	691	22.38(1)	< 0.001
✓	41	84	8	16	49		
Simple							
x	228	45	276	55	504	13.74(1)	0.0002
✓	142	60	94	40	236		
Articulate							
x	263	54	224	46	487	8.67(1)	0.003
✓	107	42	146	58	253		
Sophisticated							
x	357	51	340	49	697	6.32(1)	0.01
✓	13	30	30	70	43		
Hardworking							
x	255	48	281	52	536	4.23(1)	0.04
✓	115	56	89	44	204		
Total	370	50	370	50	740		

R = retroflex; T = tap; x = unselected checkbox; ✓ = selected checkbox.

The first characteristic associated with retroflex /r/, *caipira* ($p < 0.001$), relates to a geographical identity (often used to refer to people living in the countryside), but also relates to the speaker status for evoking the image of rural dwellers, who also tend to have lower levels of education and socioeconomic class. The *simple* trait ($p = 0.0002$) also relates to the status dimension, and *hardworking* ($p = 0.04$) relates to the solidarity dimension. The characteristics significantly favored by the tap, *articulate* ($p = 0.003$) and *sophisticated* ($p = 0.01$), also concerns speakers' status.

¹⁶ Or only 2, if considering a corrected α -level of 0.0015.

An analysis by listeners' social profiles also shows similar trends to the community as a whole: in each subgroup, many of the relevant characteristics refer to a subselection of the above, always associated with the same variants. However, new correlations also arise: female listeners associate the traits *patricinha/mauricinho* and *spoiled* to the tap, and non-native Paulistanos associate *solidary* and *sincere* to the retroflex variant.

TABLE 5 – Traits correlated with variable /r/ by listener social profile

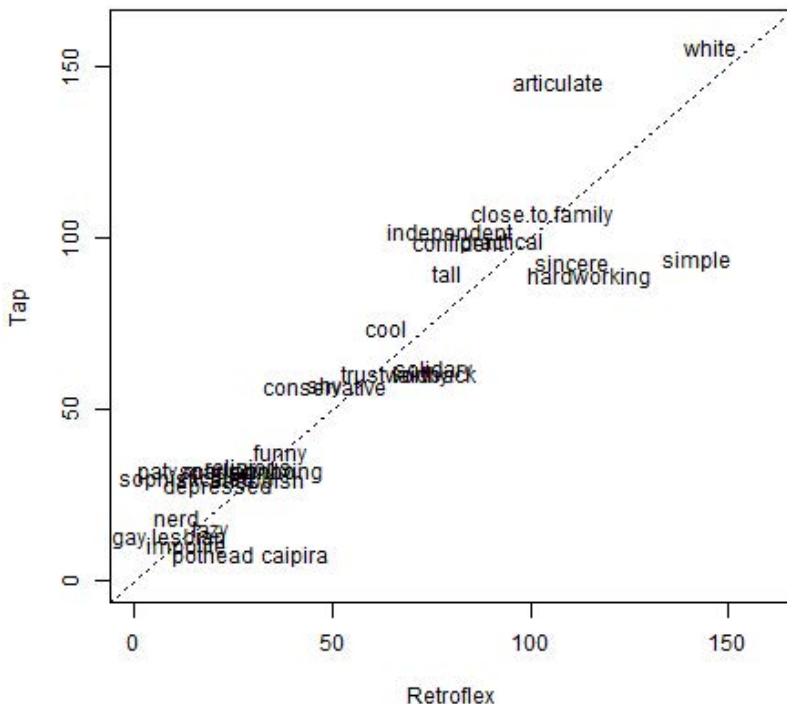
Listener group	Retroflex	Tap
Sex: Females	simple <i>caipira</i> hardworking	articulate sophisticated spoiled <i>patricinha/mauricinho</i>
Sex: Males	<i>caipira</i>	--
Area of residence: Central	<i>caipira</i> simple	articulate
Area of residence: Peripheral	--	--
Origin: São Paulo	<i>caipira</i> simple	articulate sophisticated
Origin: SP Metropolitan area	solidary	--
Origin: SP interior	<i>caipira</i> simple solidary	--
Origin: other states	sincere	--

It is also worth noting that certain traits did not correlate with variable /r/, such as *tall*, *religious*, *close to family*, differently from Lambert *et al.* (1960). In the pioneering matched-guise study in Montreal, it was found that speakers in English-guise were more positively evaluated in 7 out of 14 traits, including *height*, *good looks*, and *ambition* – mostly related to the status dimension –, whereas speakers in their French-guise were more positively evaluated in traits such as *sense of humor*, *religiousness*, and *kindness* – related to the solidarity dimension.

More generally, these analyses show that few characteristics from the checkbox list are strongly correlated with variants of coda /r/ and, even when correlations do show up, it does not necessarily entail that the characteristic was frequently selected. Figure 7 visually summarizes

these results: the frequency with which the traits were selected with retroflex- or tap-guises are represented in the x- and y-axis respectively: traits showing on the bottom right were relatively more selected in retroflex-guises and those showing on the top left, in the tap-guises. The diagonal middle line represents a “neutral” point, of equal frequency of selection. For instance, the trait *close to family* was frequently selected, but practically in identical number of times between the variants (R = 103; T = 107). The significant correlations occurred for terms relatively more distant from the neutral line. Also note that all characteristics are more frequently not selected than selected. For instance, the trait *white* (top right corner), the most frequent selection (R = 146; T = 156), represents 41% (=302/740) of the total of responses. The concentration of terms on the bottom left corner shows that the selection of checkboxes was overall infrequent. In general, participants also avoided selecting negative traits such as *annoying*, *snobbish*, *lazy*, *depressed*, *impolite* for either variant, both in face-to-face and in the online data collection.

FIGURE 7 – Frequency of selection of traits in retroflex- and tap-stimuli



This means that the described correlations between /r/ variants and certain traits don't imply that the variants themselves clearly motivated listeners in their selections, but rather that these correlations obtain only on relative grounds. Take the term *articulate*: it was more frequently selected when speakers were listened to in the tap-guise (R = 107; T = 146), which resulted in a significant correlation as seen in Table 4. But the number of times the term was selected from retroflex-stimuli (R = 107) is higher than the total number of times *caipira* – also significantly correlated – was checked for all stimuli (R = 41; T = 8). Thus, the association of a trait, far from being categorical and dependent on a specific variant, is a more complex and indirect process. Retroflex /r/ does not mean *caipira* and *simple*, and tap does not mean *articulate* and *sophisticated* by themselves, because they are competing with multiple other meanings suggested by the same stimulus. We thus need a more comprehensive model, that gives room for multiple social meanings as well as the dynamics of their inter-relations. The next section discusses one such proposal, in dialogue with Eckert's (2008) concept of the indexical field.

5 A computational approach for modeling the indexical field

It has been shown so far that variants of coda /r/ are correlated with degrees of “Paulistanity,” accent, area of residence, formality, education, social class, and personal attributes such as *caipira*, *simple*, *articulate*, and *sophisticated*. On the other hand, certain expected correlations were not observed – for instance, the association between tap /r/ and sounding “tall” or “patricinha/mauricinho,” or between retroflex /r/ and sounding “close to family,” “friendlier.” In fact, there is great variability in participants' responses to all variables, which suggests that, far from being directly related to this set of characteristics, variants of /r/ interact in a network of ideologically related meanings, upon which listeners make inferences about the speakers.

These observations are in line with Eckert's (2008) proposal of the indexical field, which conceives of meanings of variants as dynamic, potential, and emergent in interaction. The concept of indexical field opens the possibility of more complex representations of social meanings, more coherent with what is observed in speakers' usage and in listeners' perceptions. For example, it explains why not all speakers and social groups react to the same variant homogeneously; why the term *articulate*, although favored by the tap, was also frequently attributed to retroflex

stimuli; or why the correlation between /r/ and level of education does not extend to the scale of intelligence, as seen in other studies (e.g. MENDES, 2016; CAMPBELL-KIBLER, 2006). On the other hand, sociolinguists still do not have a method to compute and reliably replicate or compare such findings across studies, as is the case, for instance, with the variable rule analyses of speech production data.

This section proposes a method to compute the co-occurrence and the inter-relations among multiple variables which can represent emergent indexical fields. Minimum Spanning Trees (GOWER; ROSS, 1969; henceforth MSTs) are graphical representations of multiple correlations, in which a strong correlation between two elements is represented by a smaller distance in a bidimensional plane, and weaker or absence of correlation is represented by greater distance between two variables.¹⁷

MSTs can be built in R using the *spantree* function of the *vegan* package (OKNANSEN *et al.*, 2018).¹⁸ The *spantree* function requires a dissimilarity matrix as one of its arguments, which in turn requires a binarily coded spreadsheet. Hence the original data were recoded so that all variables had 0s or 1s for each of the participants' responses. For the scale variables, values from 1 to 3 were turned into 0 and 4-5 into 1. For the categorical variables, levels were likewise reorganized into binary variables, as lower / upper class, and less / more than 30 years old. Because City Zone is not an ordinal variable, each level was turned into a variable in itself (WestZ, NorthZ, SouthZ etc.) and coded as either checked (1) or unchecked (0). The same procedure was applied to the checkboxes: each characteristic (*tall*, *articulate*, *white* etc.) was coded binarily as checked or unchecked. Four terms in the checkboxes were discarded – *pothead*, *impolite*, *gay/lesbian*, and *nerd* –, as they were overall rarely selected (less than 30 times). After adjusting the coding, the function *Dist* from the *amap* package (LUCAS, 2018) was used to produce the dissimilarity matrix, which calculates correlations between all possible pairs of variables and outputs a matrix of *n* columns and *n* lines, *n* being the total number of variables – 63 in the present experiment.

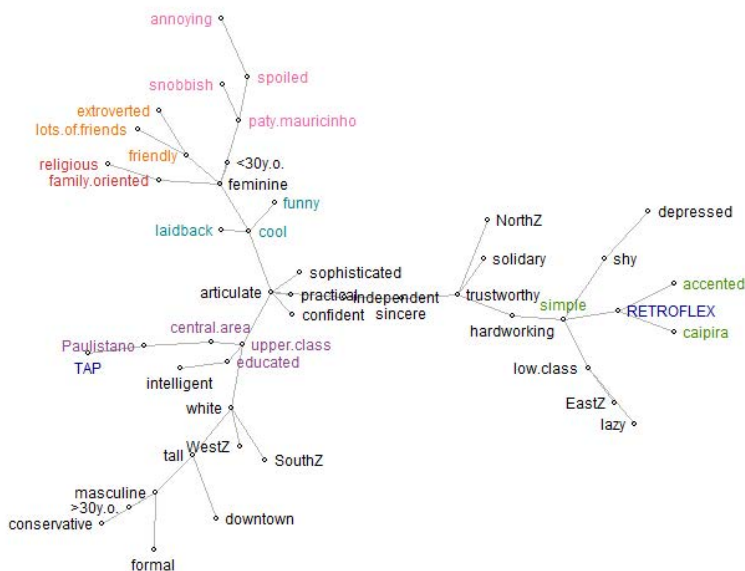
¹⁷ The argument that correlation analyses can help model the indexical field has also been put forth in Tyler (2005).

¹⁸ The *vegan* package has been originally designed for “diversity analysis, ordination methods” and “the analysis of dissimilarities” (OKNANSEN *et al.*, 2018, p. 4); though intended primarily for biologists, its multivariate analysis tools are particularly useful for sociolinguistic data.

The full code and data, from recoding participants' responses to the computation of the MSTs, can be downloaded from <https://zenodo.org/record/2548037#.XEKCi817IPY>.

Figure 8 is the visual representation of the MST. Nodes closer to one another indicate levels that co-occurred more frequently (i.e., were both 0s or were both 1s). It thus allows for an analysis not only of the relations between the variants of /r/ and other variables, but also the inter-relations among all variables in the questionnaire.

FIGURE 8 – Indexical field of variable /r/ in São Paulo Portuguese (all data)



It seems useful to first comment on how this and the subsequent figures are *not* meant to be read. First, they are not to be interpreted as a mental map of how listeners arrived at their percepts of the speaker. For example, although the terms *tap*, *Paulistano*, *central area* and *upper class* are connected in this order from left to right, it does not imply that a participant first listened to a tap, and then associated it with *Paulistano*, then with *central area*, then with *upper class* and so on, i.e., it is not claimed that they represent any specific chain of connections in any direction. Further, there is no intrinsic meaning for a term showing up on the left, on the right, at the bottom or at the top. What matters here is

the proximity between terms: the closer they are, the more likely they were to have co-occurred in participants' questionnaires, regardless of the direction from which listeners arrived at their conclusions and whether these were conscious or unconscious choices.

It should also be noted that MSTs, proposed here as *models* of an indexical field, are not meant to capture it in its entirety, as any given model is a simplified version of what it represents. It is clear that, being based on a closed questionnaire which was applied to a specific set of participants, the terms could have been different and are, necessarily, a subset of all its potential form and spread. The advantage of MSTs is the fact that they are built from observable correlation matrices that can be computed from our data.

Figure 8 thus shows that tap /r/ is close to the terms *Paulistano*, *central area* and *upper class*; being perceived as upper class, on its turn, frequently co-occurred with the perception of being *educated*, *intelligent*, *articulate*, and *white*. The retroflex variant, on the other hand, shows up closely associated with the notions of being *accented*, *caipira*, and *simple*, and the latter with *hardworking* and *low class*. The differently colored groups in Figure 8 represent clusters of terms that are consistently recurrent across different groups of participants, a point which will be further discussed ahead. This general representation of multiple correlations in the data agrees with the significant correlations seen in section 4. Here, in making explicit the relations that the participants made among multiple concepts when imagining who and how the speaker is, the MST provides a more reliable way to infer which terms are relatively more associated to one another.

Although the main focus here is on tap and retroflex /r/, it is likely that listeners didn't start with these variants in drawing their impressions on the speakers. It is possible to imagine, for instance, that the first impression of a listener was that of a professor giving a lecture, as in example (5), from the speech content and from a perception of good verbal articulation on the part of the speaker; the listener may then have consciously or unconsciously inferred the speaker's higher level of education, and possibly that he is an upper class individual who lives in a corresponding area of the city. In this scenario, listening to one or the other variant may reinforce the constructed image, lead to the revision of certain previous perceptions or even lead to the formulation of a new image altogether. It is worth mentioning that, in the face-to-face data collection, it was not uncommon for participants to change or adjust answers, both to the current and to previous speakers (although the latter occurred much less frequently).

The connections among all terms in the MST show that it is possible to arrive at any other, but with different probabilities. For example, the term *articulate* is close to the center of the MST, almost halfway between the tap and the retroflex, though a little closer to the former. This explains the correlation between the tap and sounding *articulate*, but is also in tandem with the fact that the term was frequently selected in retroflex guises. On the other hand, the term *caipira* is much closer to retroflex /r/, *accented* and *simple*, and quite far from the tap, which explains its strong correlation with retroflex /r/, even though it was selected for these guises fewer times than the term *articulate*.

Eckert's (2008) model also predicts shifts in the indexical field according to speakers, listeners, speech context, interlocutors' stances etc. Here, the experimental design was intended to minimize the effect of all these variables, but section 4 has already pointed to the fact that listeners of different social profiles show slightly different correlations. These differences can be visualized in the following figures, which show MSTs according to participants' sex (FIGURE 9), area of residence (FIGURE 10), and origin (FIGURE 11). The comparison between these diagrams and that of the general sample makes it possible to identify recurrent patterns in all groups, as well as their specificities.

Certain clusters appear in all MSTs: (i) Paulistanity-central area-upper class-educated; (ii) retroflex-caipira-simple; (iii) simple-hardworking-low class-EastZ; (iv) patricinha/mauricinho-spoiled-snobbish-annoying; (v) lots of friends-friendly-extroverted; (vi) laidback-cool-funny; (vii) religious-family oriented. These are identified by different colors in Figures 8-13. The first two are always close to the tap and the retroflex respectively, which signals the consistency of these associations in the whole community – thus exhibiting significant correlations in the statistical analyses. The correlation between the retroflex and the East Zone (and no other zone) may be explained by these networks of relations. In the community's imagination, this part of the city is associated with the working class, with simple and hardworking people. Such association is partially based on everyday experience, and partially by a process of *erasure* (IRVINE, 2001), in which certain facts are ignored, such as the massive presence of middle and upper middle-class individuals in this zone or the existence of working class in all other city zones. The perception that speakers were from the East Zone when listened to in their retroflex-guises, thus, occurs indirectly – but frequently – among the ideologically related terms.

FIGURE 9 – Indexical fields of variable /r/ in São Paulo Portuguese by participants’ sex

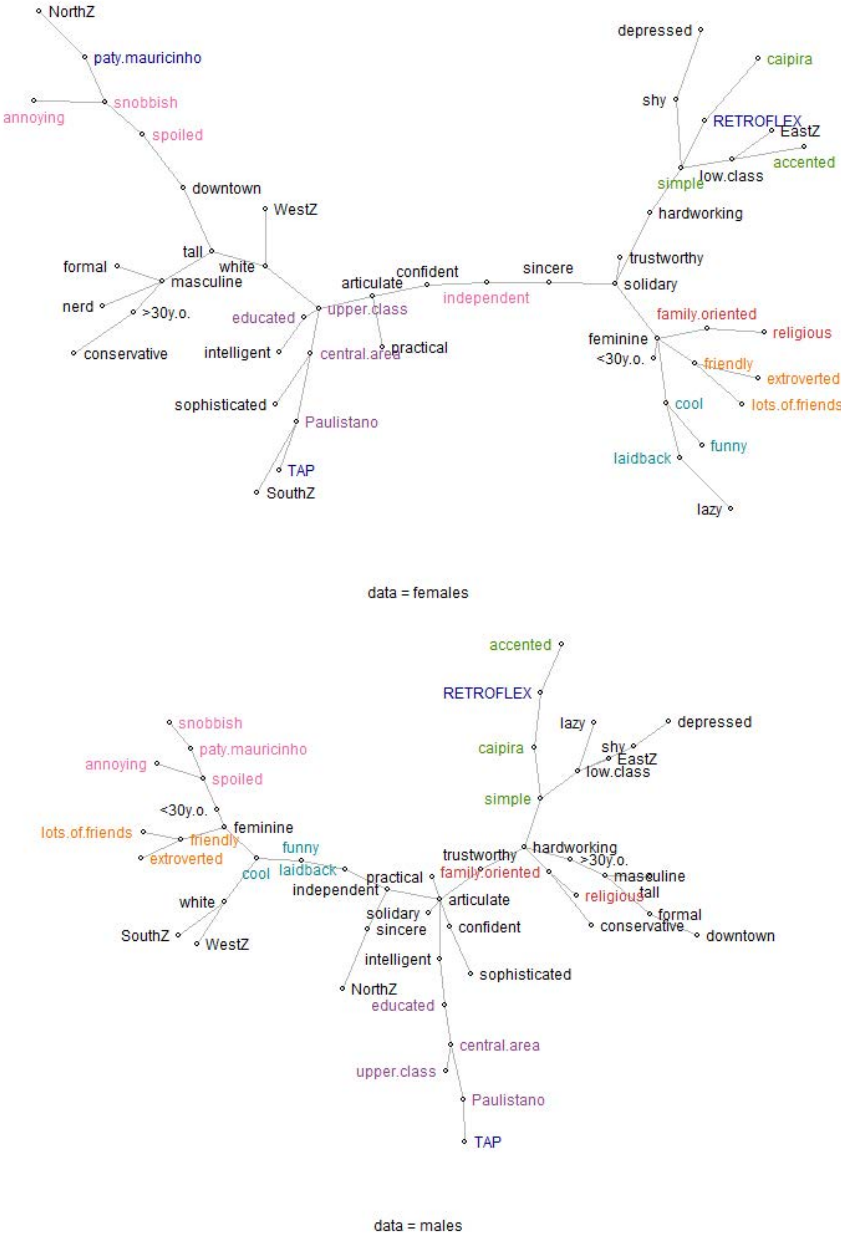
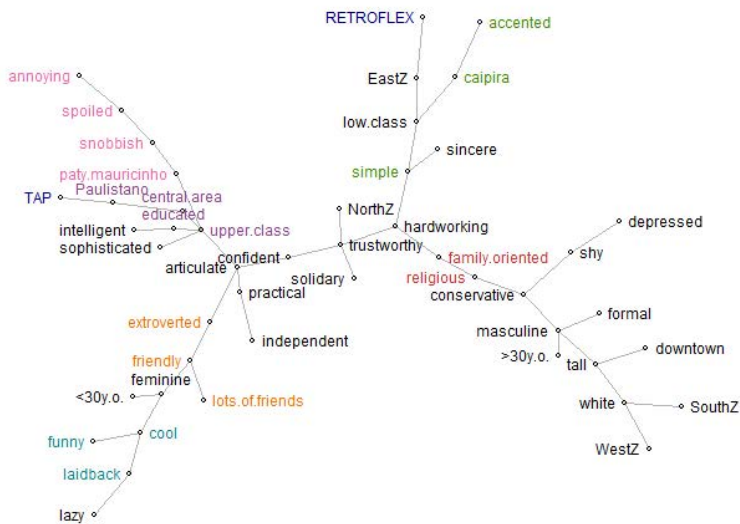
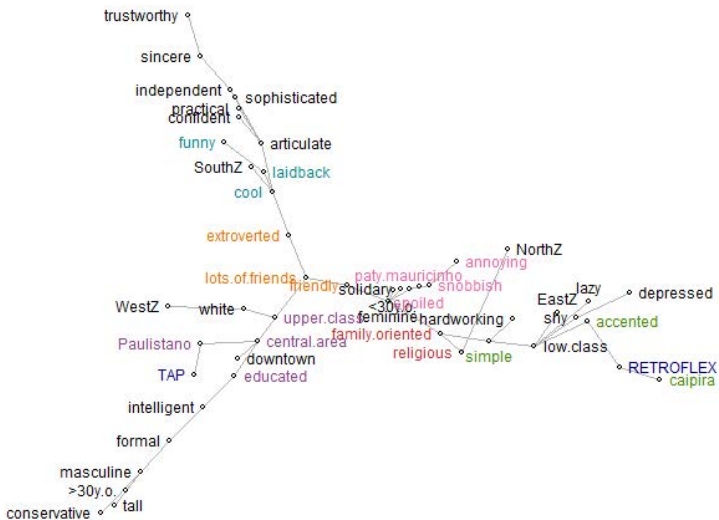


FIGURE 10 – Indexical fields of variable /r/ in São Paulo Portuguese by participants' area of residence

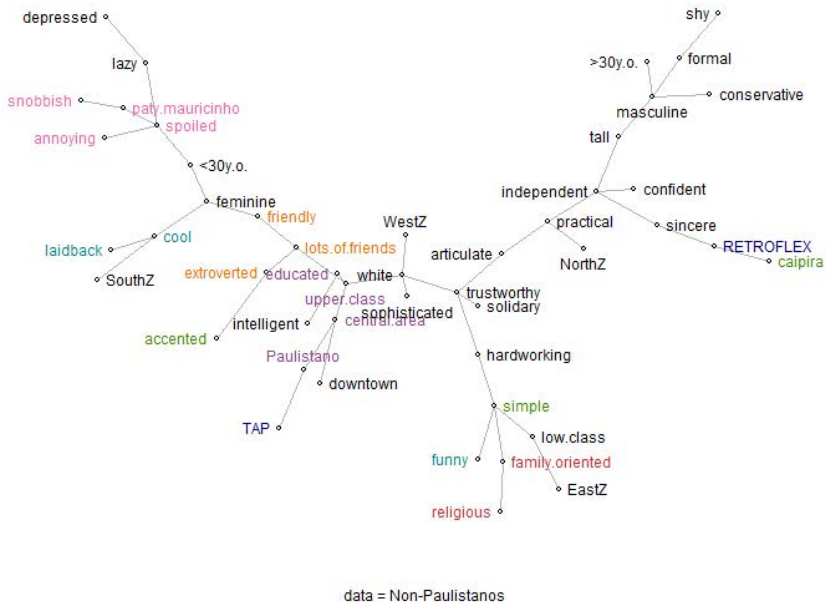


data = periphery

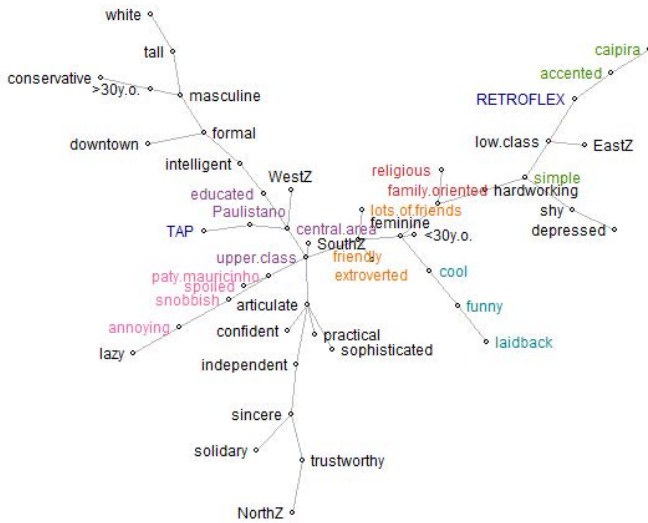


data = central

FIGURE 11 – Indexical fields of variable /r/ in São Paulo Portuguese by participants' origin



data = Non-Paulistanos



data = Paulistanos

For participants living peripheral areas (FIGURE 10), the term *accented*, although also showing up in the “retroflex-caipira-simple” cluster, is relatively farther to the retroflex – as it is mediated by low class and East Zone – than for central area residents. For non-Paulistanos (FIGURE 11), *accented* is quite far from the retroflex – and actually closer to the tap. These differences reflect previously observed correlations: for peripheral area residents, the retroflex is not considered such a strong accent (FIGURE 5 above), and for out-of-towners, both retroflex and tap are “accents”.

Other clusters are also differently placed among the MSTs. The “patricinha/mauricinho-spoiled-snobbish-annoying” cluster is closer to the tap for the females, residents of the periphery and Paulistanos, but relatively equidistant from the /r/ variants for men, central residents and non-Paulistanos. The fact that certain groups of concepts move “in bulk” is indicative of the new potential meanings of variants – in Silverstein’s (2003, *apud* ECKERT, 2008, p. 464) words, “always already immanent.” The clusters show ideologically related meanings that inhabit people’s imagination independently from specific variables and usages; but once one of the terms approximates a linguistic variant, all that cluster becomes available for new meanings. The MST model shows that not all “immanent” meanings have the same probability of association, but rather that those pertaining to a relatively stable cluster is more likely to be evoked in specific contexts. Take, for instance, the “patricinha”-cluster: for females, Paulistanos and residents of peripheral areas, it is more closely related to “upper class”; in contrast, for males, residents of central areas and non-Paulistanos, it is more closely associated with femininity and younger people (“feminine” and “<30y.o.”). Section 4 showed that variable /r/ significantly correlates more consistently with social class, but not femininity. This predicts that listeners who associate the “patricinha”-cluster with upper class – such as women – have greater probability to also associate the tap to “patricinhas” than those who associate “patricinha” with femininity (such as the males as a group). As observed, we verified a significant association between tap and “patricinhas” for women ($p < 0.02$), differently than for men ($p = 0.71$) (see TABLE 5 above).

Analyzing more subtle differences helps understand how the MSTs are built. Figure 12 compares the “Paulistanity-central area-upper class-educated” cluster for females and males. As already noted, this

cluster is remarkably similar across different social groups, and is always close to the tap. However, while *educated* is linked to *central area* via *upper class* for females, both *educated* and *upper class* are directly linked to *central area* for males. How does that obtain?

FIGURE 12 – “Paulistanity-central area-upper class-educated” clusters for females (left) and males (right), with dissimilarity indices

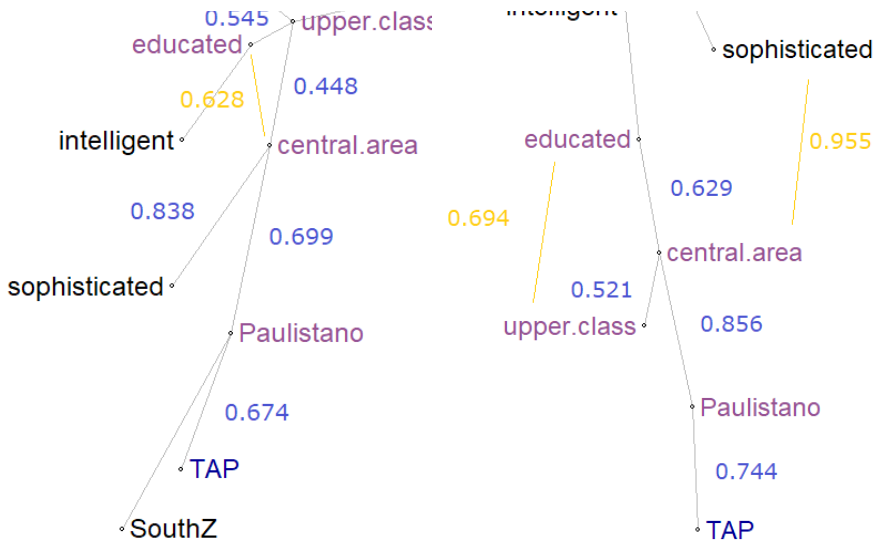


Figure 12 zooms into the “Paulistanity”-cluster for females and males, and also shows the dissimilarity indices computed by the dissimilarity matrix. Those in blue refer to nodes directly linked in the tree, and those in yellow refer to indirect relations between certain pairs. The dissimilarity indices for all pairs of relevant variables in Figure 12 are reported in Tables 6 and 7 for females and males respectively.¹⁹ In the dissimilarity matrices, smaller indices (to the minimum of zero) represent stronger correlations and, conversely, greater indices (to the maximum of 2) represent complete lack of co-occurrence in the data. Not surprisingly, Tables 6 and 7 show indices of zero across the diagonal

¹⁹ The full matrices are not shown here for concision but can be computed and visualized from the script in <https://zenodo.org/record/2548037#.XEKCi817IPY>.

row, relating a variable with itself, and maximum dissimilarity between *tap* and *retroflex*: as participants listened to stimuli with either variant, they naturally never co-occur in the data.

In the males' cluster, *central area* is directly linked to *Paulistano*, *educated* and *upper class* because the respective indices for the pair (0.856, 0.629, and 0.521) are the smallest indices for *central area*. In the females' cluster, the dissimilarity index between *educated* and *central area* (0.628) is quite similar to the one for males (0.629) but, for the former, there is yet a smaller dissimilarity index for *educated*, namely, the one between *educated* and *upper class* (0.545); thus, for females, *educated* is not directly linked to *central area*, because 0.628 is not the smallest index for each of these terms. This also explains “dead ends” in the trees: take, for instance, the node *upper class* in the males' MST. The fact that it is linked to *central area* (0.521) and no other term means that 0.521 is the smallest dissimilarity index for *upper class* and also that its dissimilarity index with other terms – say, with *Paulistano* – is not smaller than those for *Paulistano* and other terms.

TABLE 6 – Dissimilarity matrix for the “Paulistano-central area-upper class-educated” cluster and surrounding terms for females

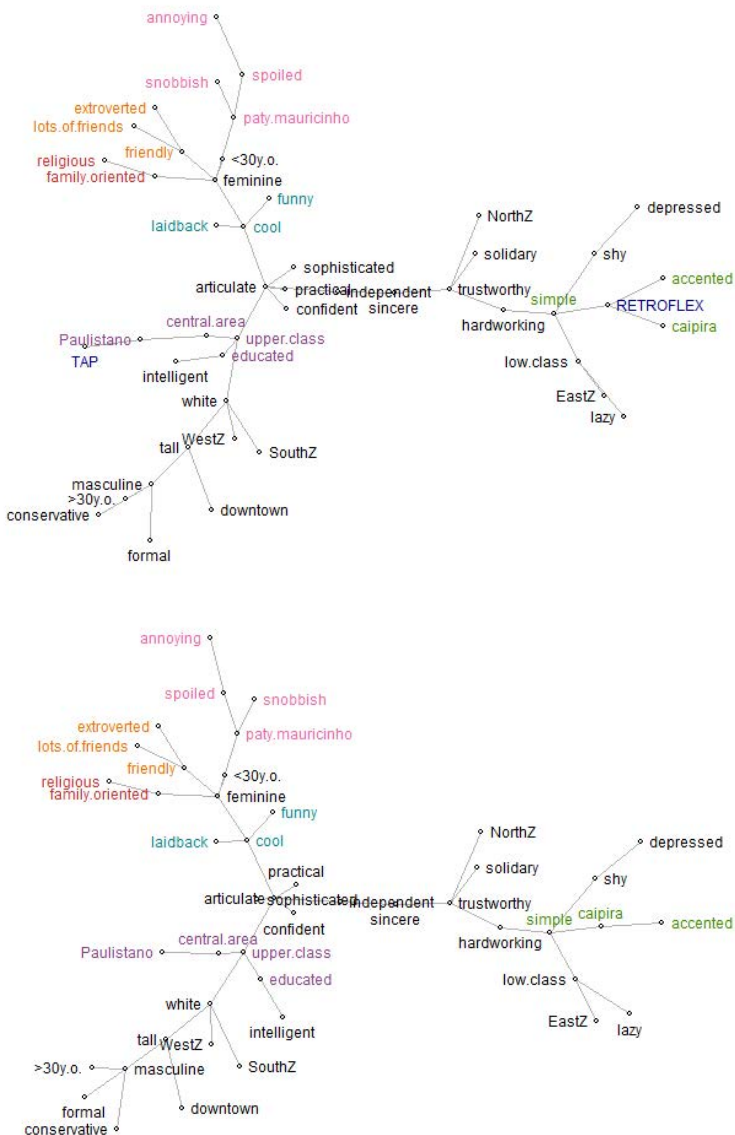
	Retroflex	TAP	Paulistano	central.area	upper.class	educated	intelligent	sophisticated
Retroflex	0.0000	2.0000	1.3252	1.2287	1.1586	1.0783	1.0411	1.1498
TAP	2.0000	0.0000	0.6748	0.7713	0.8414	0.9217	0.9589	0.8502
Paulistano	1.3252	0.6748	0.0000	0.6992	0.7679	0.7710	0.7923	0.9233
central.area	1.2287	0.7713	0.6992	0.0000	0.4479	0.6285	0.6391	0.8385
upper.class	1.1586	0.8414	0.7679	0.4479	0.0000	0.5450	0.7417	0.8477
educated	1.0783	0.9217	0.7710	0.6285	0.5450	0.0000	0.5841	0.9035
intelligent	1.0411	0.9589	0.7923	0.6391	0.7417	0.5841	0.0000	0.9093
sophisticated	1.1498	0.8502	0.9233	0.8385	0.8477	0.9035	0.9093	0.0000

TABLE 7 – Dissimilarity matrix for the “Paulistanity-central area-upper class-educated” cluster and surrounding terms for males

	Retroflex	TAP	Paulistano	central.area	upper.class	educated	intelligent	sophisticated
Retroflex	0.0000	2.0000	1.2554	1.0498	1.0827	1.0242	1.0082	1.0377
TAP	2.0000	0.0000	0.7446	0.9502	0.9173	0.9758	0.9918	0.9623
Paulistano	1.2554	0.7446	0.0000	0.8560	0.9037	0.8641	0.9304	0.9278
central.area	1.0498	0.9502	0.8560	0.0000	0.5214	0.6297	0.8467	0.9555
upper.class	1.0827	0.9173	0.9037	0.5214	0.0000	0.6939	0.8072	0.8808
educated	1.0242	0.9758	0.8641	0.6297	0.6939	0.0000	0.6526	0.9017
intelligent	1.0082	0.9918	0.9304	0.8467	0.8072	0.6526	0.0000	0.9403
sophisticated	1.0377	0.9623	0.9278	0.9555	0.8808	0.9017	0.9403	0.0000

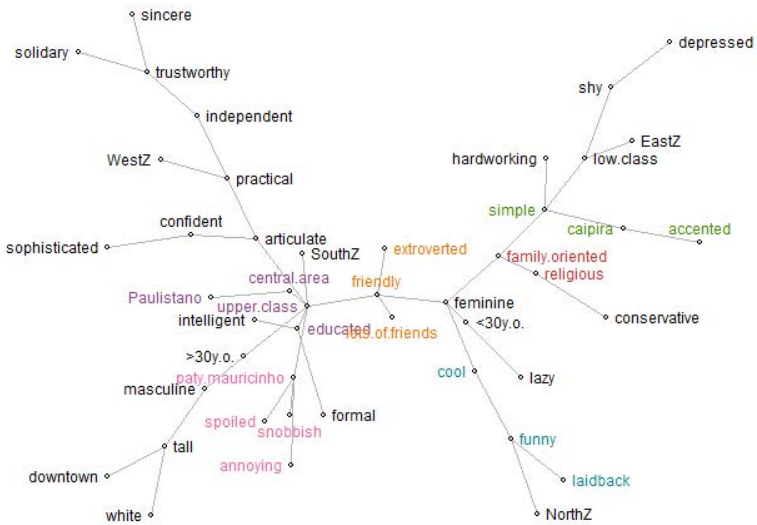
It could be argued that the terms *tap* and *retroflex* have been artificially drawn apart in all MSTs due to the experiment design, since *tap* and *retroflex* /r/ never co-occur in the stimuli, and this is in fact true. This may have serious consequences for the representation of variables which are strongly correlated with *tap* or *retroflex* /r/ (such as *Paulistano*, *upper class*, *caipira*, and *simple*), because they may have been artificially separated. Three alternative analyses were then run in order to evaluate the effect of the /r/ variants on the structure of the indexical fields as a whole: one excluding both the *tap* and *retroflex* from the dataset (diagram at the bottom in FIGURE 13), and other two excluding either the *tap* or the *retroflex* (FIGURE 14).

FIGURE 13 – Indexical field of variable /r/ in São Paulo Portuguese with (top) and without (bottom) the terms “tap” and “retroflex”

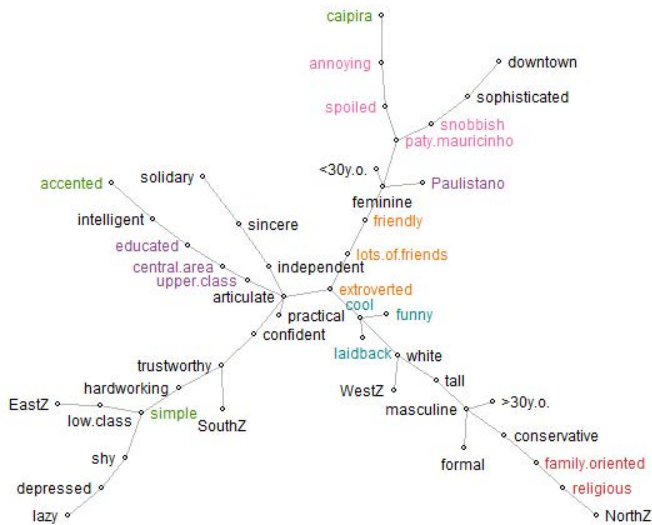


data = all (excluding the terms "tap" and "retroflex")

FIGURE 14 – Indexical fields of variable /r/ in São Paulo Portuguese by /r/ variant



data = retroflex (responses for tap /r/ excluded)



data = tap (responses for retroflex /r/ excluded)

For direct comparison, Figure 13 shows the MST for the full data (from FIGURE 8) at the top and the revised MST (excluding the terms *tap* and *retroflex*) at the bottom. There are only a few minor changes. For instance, the term *intelligent* is still connected to *educated* (and this one, on its turn, is connected to *upper class*), but now it shows up relatively closer to *SouthZ*, to reflect the fact that, in the absence of *tap*, *intelligence* is more closely related to other terms. Overall, however, the structure of both MSTs is virtually the same. Of course, excluding the terms *tap* and *retroflex* does not change the experiment design, and the fact that the correlations among multiple variables remain practically the same is indicative of the variants' strength is shaping the results.

Figure 14, on the other hand, shows more drastic changes when excluding only one of the variants (thus eliminating the potential artificial distance between certain variables). Notice that most clusters remain stable, which confirms that the ideological links between certain terms (such as *religious* and *family oriented*, and *snobbish*, *paty. mauricinho*, *spoiled*, and *annoying*) are relatively independent from variable /r/. Nonetheless, there are changes in both clusters originally linked to the /r/ variants, more specifically when considering only responses for the *tap* variant. While the clusters “Paulistanity-central area-upper class-educated” and “caipira- accented-simple” remain consistent when considering only responses to retroflex-stimuli, for the *tap* subset, the term *Paulistano* is separated from the “central area-upper class-educated” cluster, and the “caipira”-cluster is broken apart completely. This suggests that these ideological connections only emerge in face of the presence of the marked variant in the community and reinforces the dynamic and contextual nature of emergent social meanings.

Hence, in describing and interpreting the MSTs, it has been made explicit how they relate to the correlation results from the previous section. In this regard, MSTs can function as more falsifiable and replicable visual representations of the “constellation of meanings that are ideologically linked.” Further, the analysis of MSTs not only illustrates these correlations, but makes it possible to describe regularities among different groups and predict the probability of new social meanings to be associated with linguistic variables. Hence, MSTs can represent the dynamic relation of linguistic variables and their potential social meanings, while also demonstrating that these relations are not fortuitous, chaotic or radically subjective: there is structure in these relations and

certain inferences are more likely than others. A coherent model of the social meanings of variation ought to encompass such links that are part of the individuals' communicative competence.

6 Conclusion

The analyses of a matched-guise experiment on the realizations of coda /r/ in São Paulo Portuguese, as tap or retroflex, have shown that the main meanings of the variants refer to geographical identities (capital city vs. interior; center vs. periphery), that such meanings extend to relative status of speakers in the community and, to a minor degree, to inferences about speakers' personal characteristics. All the significant correlations follow the predicted direction: speakers in retroflex-guise are perceived more negatively in the status variables (social class, level of education, formality, area of residence, articulation and sophistication), and more positively in traits associated to the solidarity and dynamism dimensions (work, simplicity, sincerity, solidarity). These results are in tandem with previous studies that noticed that languages, varieties, and variants favored by less privileged speakers tend to be perceived negatively in the status dimension and positively in the solidarity dimension.

In this sense, it is more interesting to pose the question of why certain expected correlations do not appear, such as the one with speakers' intelligence and femininity/masculinity (cf. MENDES, 2016), and with traits such as looks and religiousness (cf. LAMBERT *et al.*, 1960). MSTs show that whereas any one term/social meaning is potentially linked to another, some of them are consistently clustered across different groups in a community, whereas others may float more freely. It was shown in particular that ideological connections pertaining to the /r/ variants – namely, the “Paulistanity-central area-upper class-educated” and “caipira-accented-simple”-clusters, associated with the tap and retroflex variants respectively – emerge only in face of the marked variant in the community, when retroflex /r/ is heard. In all cases, potential meanings, although not fixed, are also not random: certain ideological links are more likely to be made by certain groups – and presumably, in certain contexts –, and such probability can be modeled.

Significant interactions were also observed between participants' area of residence and place of origin with perceptions of speakers' degree of “Paulistanity” and “accentedness.” A model of sociolinguistic

perceptions and social meanings of variants should describe in detail the differences between groups of listeners, communities, and variables under investigation, i.e., it should account for the inferences made by the listeners as well as correlations that turn out to be insignificant or different from those for other variables and communities.

Hence, starting from Eckert's (2008) concept of indexical fields, a computational model of how different social meanings come to be associated with certain variants in a non-impressionistic, falsifiable, and replicable manner has been presented. The model provides a more objective interpretation of the observed correlations, as well as the prediction of probability of new meanings to be attributed to sociolinguistic variables. It thus reinforces the dynamic and structured character of sociolinguistic perceptions and evaluations.

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