Prosodic correlates of the expression of pure sarcasm and sarcastic irony in Brazilian Portuguese

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Abstract

The study reported here aimed at investigating whether sarcastic irony is expressed in Brazilian Portuguese with an acoustic pattern distinct from that of pure sarcasm and neutral speech. A total of 236 utterances (48 exemplars of sarcastic irony, 84 of pure sarcasm, and 104 neutral), produced by 11 speakers (6 female; 5 male) and validated by a separate group of subjects in a perception experiment, were subjected to automatic acoustic analysis for the extraction of 15 acoustic parameters. The results showed that, in relation to the neutral utterances, sarcastic irony is expressed with smaller long-term average spectrum (LTAS) spectral slope, greater LTAS standard deviation, greater fundamental frequency (f0) first derivative standard deviation, lower f0 median, maximum and minimum, wider f0 interquantile range, and greater values of jitter and shimmer. Compared with pure sarcasm, sarcastic irony is expressed with a significantly greater LTAS spectral slope. We concluded, therefore, that sarcastic irony is expressed in Brazilian Portuguese with a specific pattern of changes in acoustic parameters as compared to neutral speech and pure sarcasm.

Index Terms: speech prosody, sarcastic irony, Brazilian Portuguese

1. Introduction

The verbal human communication involves not only the information directly accessible by the interlocutor in the literal sense of the words used, but also implicit (indirect) information that must be correctly inferred so that the dialogue partners can successfully communicate. A very common case of indirect communication is verbal irony, through which the speaker communicates something different from (or the opposite of) what the words he/she used usually mean [1]. Verbal irony is part of a set of intentional and controlled behaviors that interlocutors adopt to express their opinion, belief and/or knowledge. These behaviors are known as attitudes [2]. There are several subtypes of verbal irony, each one with a specific communicative function [3]. In this work, we focus on the most common of them: sarcastic irony. This attitude consists in the combination of irony with sarcasm, and is used to express a criticism or a comment directed at an object, event or person [4, 5].

As the term "sarcastic irony" suggests, in this work we understand (along with other authors, e.g. [4-7]) that irony and sarcasm are independent from each other, i.e., that sarcasm alone is not a subtype of verbal irony. Just as verbal irony can be used without sarcasm (as in the use of the sentence "What a beautiful day!" to refer to a rainy day), sarcasm can exist without irony (as in the sentence "You are really bad at this!", spoken to someone who has just lost a game, a case in which there is no inversion of lexical meaning). Sarcasm is, therefore, a negative attitude, used to tease, criticize and/or hurt the interlocutor and can be expressed without the ironic meaning clash [4, 7]. We refer to this attitude as pure sarcasm, since many authors use the term "sarcasm" to refer to the combination of irony and sarcasm (which we call here "sarcastic irony").

Experimental research on the expression of sarcastic irony in speech started to be conducted about a decade ago and therefore constitutes a relatively new field of scientific investigation [7]. These studies, carried out mainly for English, have indicated that sarcastic irony is expressed (in relation to neutral or non-ironic speech), in general, by a reduced speech rate (and consequently with longer duration of utterances), as well as by changes in fundamental frequency and intensity. Regarding fundamental frequency, there seem to be interlinguistic differences. In English and German (Germanic languages), for example, the fundamental frequency values are lower in the expression of sarcastic irony, whereas in Italian and French (Romance languages) and in Cantonese, they are higher [7-11]. Intensity is reported to be, in general, lower both in mean and in range, but with some exceptions, as in [12]. With regard to Brazilian Portuguese (henceforth BP), prosodic studies on the expression of sarcastic irony are even scarcer. In a study with an adult BP female speaker, [13] investigated the expression of seven attitudes, including irony, and showed that irony was expressed with higher fundamental frequency mean and range in relation to the neutral expression. The study by [2] examined the production of 5 sentences produced by two speakers (a male and a female), and confirmed the results of [13] for irony with respect to the fundamental frequency range. However, the ironic speech presented a lower fundamental frequency mean than the neutral condition for both speakers.

The present study was conducted to investigate whether sarcastic irony is expressed in BP with a distinct acoustic pattern from that of pure sarcasm and neutral speech. In light of previous research, we expect BP speakers to make use of specific changes in some acoustic parameters to differentiate sarcastic irony from pure sarcasm and neutral speech. However, given the inconsistencies found across studies, it is not possible to predict the direction of these changes.

2. Method

2.1. Target sentences

In order to minimize the influence of variation at the segmental level on the acoustic parameters, this study was carried out with 10 BP target sentences, which were inserted in short dialogues designed to help the speakers to express sarcastic irony and pure sarcasm. Only the target sentences were considered for analysis. Before acting out the dialogues, the speakers were asked to produce the target sentences in isolation, and these recordings were taken as the control utterances (hereafter referred to as "neutral"). The target sentences used in this study were as follows:

1) Você tem que tomar cuidado com quem fala.

(You should be careful with whom you speak.)

2) Que tal pensar no que vai fazer antes de agir?

(What about thinking about what you're going to do before taking an action?)

3) Você deveria passar protetor antes de sair de casa.

(You should use a sunscreen lotion before leaving home.)

4) Que tal prestar atenção no que come da próxima vez?

(What about paying attention to what you eat next time?)

5) Você deveria pensar antes de falar essas coisas.

(You should think before saying those things.)

6) Que tal comprar um carro que não precise de tanta manutenção?

(What about buying a car that does not need so much maintenance?)

7) Você deveria tomar cuidado com suas novas amizades.

(You should be careful with your new friends.)

8) Que tal se vestir como gente da próxima vez?

(What about dressing like a person next time?)

9) Você deveria expor seus sentimentos mais frequentemente.

(You should expose your feelings more often.)

10) Que tal torcer para o Brasil da próxima vez?

(What about supporting Brazil next time?)

2.2. Speakers and recording procedure

This study was based on the production of 11 Brazilian speakers (6 female, mean age 23 years, range 19-25; 5 male, mean age 25 years, range 18-37), who were recruited among students at University of Campinas. Most of them speak a variety of BP from the State of São Paulo, only two of them speaking the variety from the State of Rio de Janeiro. They had no known speech or hearing disorders.

The speakers were recorded in a sound treated room, with Shure "Dynamic Cardioid" 8900 and Shure "Dynamic Supercardioid" Beta 58A microphones connected to a Panasonic RR-US551 digital recorder each, and the recordings were sampled at 44.1 kHz. Each speaker acted out the dialogues with another speaker (or, in a few cases, with the experimenter), who was in the next room. They were standing in front of the microphone so as not to limit their body movement and could see each other through a glass window and hear each other with headphones, which were also connected to the digital recorders. They were asked to familiarize themselves with the dialogues first and then try to act as if they were really living the situation described. In case the speakers were not satisfied with their performance, they were asked to record that dialogue again. A whole recording session took about one hour and a half.

2.3. Perceptual validation of the utterances

In order to verify that the utterances of the sarcastic irony, pure sarcasm and neutral conditions are recognized as intended by the speakers, the 330 recorded utterances (10 target sentences X 3 conditions X 11 speakers) were subjected to a perception test. The experiment was carried out over the Internet in two different sessions. The first session was run through the "Survey Gizmo" online software (http://www.surveygizmo.com/) and comprised 210 utterances (corresponding to the production of 7 speakers). Sixteen subjects (9 female, mean age 27 years, range 20-35; 7 male, mean age 29 years, range 21-37), who did not take part in the recordings, participated in this session. Due to technical reasons, the second session had to be carried out in a different platform, keeping, however, the structure of the experiment as similar as possible to that of the first session. It was then run through the PsyToolkit online software [14, 15] and comprised the remaining 120 utterances. Sixteen subjects (9 female, mean age 28 years, range 19-35; 7 male, mean age 27 years, range 19-35), not all the same as those of the first session and who also did not take part in the recordings, participated in. The first session took about 30 minutes to be completed, whereas the second session took about 15 minutes. All the listeners were native speakers of BP, have lived most part of their life in Brazil and had no known speech or hearing disorders.

In the experiment, listeners were presented with one utterance at a time and chose one of the three options displayed on the screen (sarcastic irony, pure sarcasm and neutral), according to which attitude they thought the speaker expressed. Before starting the experiment, they received definitions and examples for each attitude. They were asked to use earphones and to do the experiment in a quiet room. The audio was reproduced automatically as the page was finished loading and the listener could repeat it one more time if necessary.

The recognition rate for the validation of the utterances was determined by means of a binomial test with $n = 16$, $\pi = 1/3$, and $\alpha = 0.05$. Therefore, an utterance was considered valid if its intended attitude was correctly identified by at least 9 listeners (56%), since, according to this test, the probability of 9 or more subjects out of 16 correctly identify by chance the intended attitude of an utterance is less than 0.05. Based on this criterion, 236 utterances (48 exemplars of sarcastic irony, 84 of pure sarcasm, and 104 neutral) were retained for further analyses.

2.4. Acoustic analysis

To determine which acoustic features of speech are used by BP speakers to express sarcastic irony and pure sarcasm, fifteen acoustic parameters were automatically computed from the 236 validated utterances by means of a script implemented for the software Praat [16]. These parameters were as follows:

- Fundamental frequency (measured in semitones relative to 100/200 Hz for male/female speakers): f0 median, f0 minimum (0.005 quantile), f0 maximum (0.995

quantile), f0 interquantile range (0.95 quantile - 0.05 quantile), and f0 skewness;

- F0 first derivative: mean, standard deviation, and skewness;
- Global intensity: standard deviation;
- Spectral emphasis: the difference between the intensity in dB of the whole spectrum and that of the 0 - 1.5*f0median (Hz) band [17];
- Long-term average spectrum (LTAS): standard deviation, and slope (the difference of mean intensity in dB between the bands 0 – 1000 Hz and 1000 – 4000 Hz);
- Voice quality: jitter (local), shimmer (local), and Harmonics-to-Noise Ratio (HNR). Jitter is a measure of the cycle-to-cycle variability in period duration, whereas shimmer measures the cycle-to-cycle variability in period amplitude. HNR indicates the degree of acoustic periodicity (the ratio between the periodic part and the noise part of the speech signal).

Table 1: *Mean values of the acoustic parameters on each condition. The * indicates that there is at least one significant difference between group means for that parameter. See the text for more information. st = semitones; SarcIron = sarcastic irony; PureSarc = pure sarcasm.*

Parameter	Mean values		
	SarcIron	PureSarc	Neutral
*f0 median	0.2 st	0.99 st	2.3 st
*f0 interquantile range	8.4 st	8.6 st	6.5 st
*f0 maximum	4.4 st	5.3 st	5.1 st
*f0 minimum	-4.8 st	-4.1 st	-2.4 st
*f0 skewness	-0.038	-0.003	-0.099
f0 first derivative mean	-0.91 Hz/s	-1.09 Hz/s	-0.76 Hz/s
*f0 first derivative standard deviation	3.67 Hz/s	4.19 Hz/s	3.03 Hz/s
*f0 first derivative skewness	-0.15	0.02	-0.41
global intensity standard deviation	15.59 dB	15.46 dB	14.87 dB
*spectral emphasis	12.82 dB	13.95 dB	11.95 dB
* LTAS slope	10.84 dB	9.71 dB	12.58 dB
* LTAS standard deviation	34.93 dB	36.08 dB	31.22 dB
* jitter	0.0110	0.0114	0.0094
* shimmer	0.120	0.118	0.111
* HNR	7.56 dB	7.54 dB	8.61 dB

3. Results

To examine the effect of attitude on each acoustic parameter, we performed one-way ANOVA models with attitude (factor with 3 levels: sarcastic irony, pure sarcasm, neutral) as the independent variable and each acoustic parameter as the dependent variable. When the assumptions of normality and/or homoscedasticity (tested for with Shapiro-Wilk and Fligner-Killeen tests) were not met, the non-parametric equivalent Kruskal-Wallis rank sum test was used instead. Post-hoc

comparisons were performed with Tukey HSD test (after ANOVA) or with the Wilcoxon rank sum test with the Bonferroni adjustment for the p-value (after the Kruskal-Wallis test). Effect sizes were estimated in terms of the eta-squared measure (η^2). For the Kruskal-Wallis test, η^2 was computed using the *H*-statistic following [18]. The statistical analyses were carried out using the R package [19]. Significance levels were set to 0.05. Table 1 shows the mean values of the acoustic parameters on each condition.

3.1. Fundamental frequency

The Kruskal-Wallis test revealed a statistically significant difference in *f0 median* between attitudes [$\chi^2(2) = 28.039$, $p < 10^{-06}$, $\eta^2 = 0.11$]. The post-hoc analysis showed that neutral was significantly different from sarcastic irony ($p < 10^{-04}$) and from pure sarcasm ($p < 0.001$). This was also the case with *f0 interquantile range* [$\chi^2(2) = 19.416$, $p < 10^{-04}$, $\eta^2 = 0.07$], for which there was a significant difference between sarcastic irony and neutral ($p < 0.01$) and between pure sarcasm and neutral ($p < 0.001$). *F0 maximum* presented only a significant difference between neutral and sarcastic irony [Kruskal-Wallis: $\chi^2(2) = 10.837$, $p < 0.01$, $\eta^2 = 0.04$]. With respect to *f0 minimum*, there were significant differences between sarcastic irony and neutral ($p < 0.01$) and between pure sarcasm and neutral ($p < 0.01$) [Kruskal-Wallis: $\chi^2(2) = 16.812$, $p < 0.001$, $\eta^2 = 0.06$]. Finally, the Kruskal-Wallis test also indicated a statistically significant difference in *f0 skewness* between attitudes [$\chi^2(2) = 6.2113$, $p < 0.05$, $\eta^2 = 0.02$]. The post-hoc analysis revealed that the significant difference is between pure sarcasm and neutral ($p < 0.05$).

3.2. Fundamental frequency first derivative

There was no statistically significant effect of attitude on the mean values of f0 first derivative. However, the Kruskal-Wallis test indicated a significant effect on *f0 first derivative standard deviation* [$\chi^2(2) = 29.96$, $p < 10^{-06}$, $\eta^2 = 0.12$]. The post-hoc analysis revealed significant differences between neutral and sarcastic irony ($p < 0.05$) and between neutral and pure sarcasm ($p < 10^{-06}$). In addition, the difference between sarcastic irony and pure sarcasm was marginally significant ($p < 0.08$).With regard to the *f0 first derivative skewness*, the ANOVA showed a significant effect of attitude [$F(2,233) = 4.575$, $p < 0.02$, $\eta^2 = 0.04$]. The difference between group means was significant for the pure sarcasm-neutral pair ($p < 0.01$).

3.3. Intensity

There was no statistically significant effect of attitude on *global intensity standard deviation*. The Kruskal-Wallis test indicated a significant effect on *spectral emphasis* [$\chi^2(2) = 11.407$, $p < 0.01$, $\eta^2 = 0.04$], and the post-hoc analysis revealed a significant difference between neutral and pure sarcasm ($p < 0.01$).

3.4. Long-term average spectrum

The ANOVA showed a significant effect of attitude on the *LTAS slope* [$F(2,233) = 30.91$, $p < 10^{-11}$, $\eta^2 = 0.21$]. The post-hoc comparisons revealed significant differences between neutral and sarcastic irony ($p < 0.001$), between neutral and pure sarcasm ($p < 10^{-06}$), and between sarcastic irony and pure sarcasm ($p < 0.05$). With respect to the *LTAS standard deviation*, the ANOVA also indicated a significant effect of attitude [$F(2,233) = 23.34$, $p < 10^{-09}$, $\eta^2 = 0.17$]. The Tukey

HSD post-hoc test revealed significant differences between neutral and sarcastic irony ($p < 0.001$) and between neutral and pure sarcasm ($p < 10^{-06}$).

3.5. Voice quality

A statistically significant effect of attitude on *jitter* was indicated by the Kruskal-Wallis test [$\chi^2(2) = 26.316$, $p < 10^{-05}$, $\eta^2 = 0.10$]. The post-hoc analysis revealed significant differences between neutral and sarcastic irony ($p < 0.01$) and between neutral and pure sarcasm ($p < 10^{-05}$). A significant effect on *shimmer* was also observed [Kruskal-Wallis: $\chi^2(2) = 8.7678$, $p < 0.02$, $\eta^2 = 0.03$]. There was a significant difference between neutral and sarcastic irony (Wilcoxon test: $p < 0.02$). Finally, there was also a significant difference between group means for *HNR* [Kruskal-Wallis: $\chi^2(2) = 7.817$, $p < 0.03$, $\eta^2 = 0.02$]. For this parameter, the significant difference was between pure sarcasm and neutral ($p < 0.05$).

4. Discussion

This study aimed at investigating whether sarcastic irony is expressed in Brazilian Portuguese with a distinct acoustic pattern from that of pure sarcasm and neutral speech. The results showed that a number of acoustic parameters extracted from the utterances significantly distinguished sarcastic irony from neutral speech. In descending order of eta-squared values, these parameters were: LTAS slope, LTAS standard deviation, f0 first derivative standard deviation, f0 median, jitter, f0 interquantile range, f0 minimum, f0 maximum, and shimmer.

The two most robust measures come from the long-term average spectrum, a measure that is particularly useful for reducing the effect of individual linguistic segments on the spectral structure of speech [20]. The sarcastic irony utterances presented, on average, a smaller LTAS spectral slope in relation to the neutral exemplars (Figure 1), which indicates more energy concentrated in the harmonics of higher frequencies and a greater vocal effort used in the production of these utterances [17]. This was also the only parameter which distinguished sarcastic irony from pure sarcasm, the latter presenting a significantly lower mean than the former. The pure sarcasm utterances were, thus, expressed with greater vocal effort than the exemplars of sarcastic irony and of neutral speech. This result is not surprising, given that the pure sarcasm attitude is closely related to the emotion of anger, since the speaker who uses this negative attitude seeks to scold and hurt the dialogue partner. The literature on the vocal expression of emotion shows that anger is expressed with an increase in high-frequency energy due to a greater vocal effort [21]. The smaller LTAS spectral slope was linked to a greater spectral standard deviation, with both sarcastic irony and pure sarcasm exhibiting, on average, greater values for the LTAS standard deviation than the neutral speech.

The next most efficient parameter, f0 first derivative standard deviation, is used as a means of revealing abrupt changes in the intonation contour [22]. Both sarcastic irony and pure sarcasm had a greater variability in the f0 first derivative than the neutral speech, brought about by an increase in the changes of the intonation contour of these utterances. Future research should take a closer look at these contours, in order to examine whether they exhibit specific patterns for these attitudes. The fundamental frequency-related parameters also played a role in differentiating sarcastic irony from neutral speech. With regard to f0 median, which was the

most robust of them, sarcastic irony was expressed on average with 2 semitones lower than neutral speech. It was also expressed with a lower f0 maximum (0.7 semitone lower) and lower f0 minimum (2.4 semitones lower) than neutral speech, which resulted in a widened f0 interquantile range (almost 2 semitones wider). With the exception of f0 interquantile range, this result is similar to findings obtained for Germanic languages such as Standard Northern German [7] and English [8], but contrary to those obtained for other Romance languages such as Italian [11] and French [10], and also for Cantonese [9]. Although this finding may seem surprising at first (given that one expects the f0 changes for Brazilian Portuguese to be similar to other Romance languages), it is consistent with the study by [2].The "fourth prosodic parameter", voice quality [23], stood out as relevant through the measures jitter and shimmer. The sarcastic irony utterances exhibited, on average, slightly greater fluctuations in cycle-to-cycle duration (0.2% greater) and in cycle-to-cycle amplitude (0.86% greater). This result confirms previous findings which suggested that voice quality is also manipulated by speakers to express sarcastic irony [7, 8], and emphasize the need for future research to further investigate the use of voice quality on the expression of attitudes.

5. Conclusions

The present study has shown that sarcastic irony is expressed in Brazilian Portuguese with a different acoustic pattern from that of neutral speech and of pure sarcasm. In relation to the neutral utterances, this pattern is characterized by smaller LTAS spectral slope, greater LTAS standard deviation, greater f0 first derivative standard deviation, lower f0 median, maximum and minimum, wider f0 interquantile range, and higher values of jitter and shimmer. Sarcastic irony differed from pure sarcasm with respect to the LTAS spectral slope, for which it had a significantly higher mean, as can be seen in Figure 1. As the difference between these two attitudes regarding the f0 first derivative standard deviation was marginally significant, it is possible that, with more exemplars of them, this difference be also revealed by other acoustic parameters.
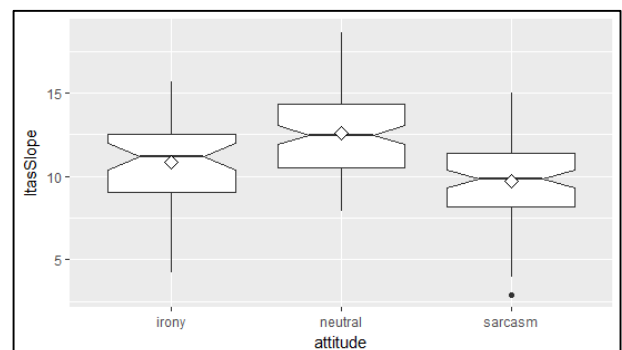

Figure 1: *LTAS slope distributions according to the levels of the factor ATTITUDE. The group means are represented by white diamonds.*

6. Acknowledgements

7. References

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