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Articles

Emotional speech prosody: How readers of different educational levels process pragmatic aspects of reading aloud

Prosódia da fala emotiva: Como leitores de diferentes níveis de escolaridade processam aspectos pragmáticos na leitura em voz alta

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ABSTRACT

In order to correlate reading proficiency and prosodic aspects, we characterized the reading aloud of readers at different levels of education regarding the acoustic behavior of target phrases under the scope of basic emotions: joy, anger and sadness, as well as in a neutral way. We seek to

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show how these different reader profiles process pragmatic aspects of the written text. For this, we produced texts whose semantic contexts incited the aforementioned emotions. Texts were read aloud and recorded for acoustic analysis. Raw scores were statistically analyzed. The statistical test showed significant differences across the different emotions, as well as between different emotions and the neutral form, for more schooled individuals. We found that acoustic values of F_0, intensity and speech rate are significantly increased in emotions such as joy and anger and decreased in sadness.

Keywords: *reading proficiency; prosody; emotions.*

RESUMO

A fim de correlacionar proficiência leitora e aspectos prosódicos, caracterizou-se a leitura em voz alta de leitores em diferentes níveis de escolaridade quanto ao comportamento acústico de frases alvo sob o escopo das emoções básicas alegria, raiva e tristeza, bem como na forma neutra. Buscou-se mostrar como estes diferentes perfis de leitores processam aspectos pragmáticos do texto escrito. Para isso, foram produzidos textos cujos contextos semânticos incitavam as emoções supracitadas. Os textos foram lidos em voz alta e gravados para análise acústica. Os escores brutos foram submetidos a análises estatísticas. O teste estatístico evidenciou diferenças significativas entre as diferentes emoções, bem como entre as diferentes emoções e a forma neutra, para indivíduos mais escolarizados. Verificamos que valores acústicos de F_0, de intensidade e de taxa de elocução são significativamente aumentados em emoções como a alegria e a raiva e diminuídos na tristeza.

Palavras-chave: *proficiência leitora; prosódia; emoções.*

1. Introduction

Prosody has currently been the scope of research on the process of reading. Researchers such as Kuhn and Stahal (2003), Leite (2012), Rasinski (2006), Santos et al. (2019) have highlighted the importance of prosody in characterising fluent reading. Prosody can either signal that the reader is understanding the text (Cagliari, 1999), or it can help the reader to organize the ideas of the text (Leite, 2012). The literature does

not show a consensus on the definition of the concept of reading fluency, however, it points out that, to define reading fluency, it is necessary to consider three fundamental components: the ability with which the reader correctly decodes the text words effortlessly; the skill with which the reader applies prosodic features, from prosodic features linked to syntax (in the case of intonational differentiation of different sentence modalities) to features linked to semantics (expressive reading); as well as the skill with which the reader understands the text read.

Studies such as those by Kuhn and Stahal (2003), Leite (2012) and Rasinski (2006) highlight that the prosodic aspects such as intonation, intensity, rhythm, pitch variation and pauses are resources that speakers/readers use to convey both linguistic aspects expressed by phonetics, morphology and syntax, up to semantic/pragmatic aspects such as the speaker attitudes (politeness, sarcasm, irony, authoritarianism), as their emotions (anger, joy, sadness, etc.) are needed of the construction of meaning.

Cagliari (2002) states that prosody goes beyond the role of decorating the text, it plays a fundamental role in making the text understandable. In the same line, Breznitz (2006), Kuhn and Stahal (2003) and Shereiber (1991) argue that fluent reading is necessary for text comprehension and should be linked to the proper procedure, involving different prosodic aspects. Cagliari (1996) states that the proper use of prosody during reading is an indicator that the reader understands the text. Thus, prosody must be understood as an essential factor in the analysis and characterization of a reader in terms of proficiency (Cagliari, 1996; Rasinski, 2006).

Considering this background, this research focuses on how readers at different stages of schooling work out pragmatic aspects of written text, such as the emotions of the speakers, and how they use them when reading aloud.

2. The importance of prosody for reading fluency

Although research on reading proficiency is not new, only more recently, with the creation of new research methods and technological

advances, such as the inception and development of the neurosciences, the research field on reading processing has expanded. We started to think about concepts related to brain processing, interactive processes, as well as the mobilization of various cognitive mechanisms involved in the reading process (Santos & Navas, 2002; Scliar-Cabral, 2012).

More recent studies have pointed out the relevance of prosody in characterising fluent reading, in addition to aspects such as automatic word recognition and textual comprehension (Breznitz, 2006; Kuhn & Stahal, 2003; Rasinski, 1990; Shreiber, 1991). Cagliari (1989) states that, during reading the reader acts as a speaker, recovering all the graphic marks present in the written text, so that the reading gets as close as possible to what would constitute oral speech.

Prosody is extremely important for the language and, above all, for the spoken modality. It encompasses physical parameters of sound such as pitch, intensity, duration, pause, speech rate, intonation, accent and rhythm of natural languages (Scarpa, 1999). These parameters constitute a range of possibilities to express the most varied communicative intentions, from banal everyday information to issues related to mental states: joy, sadness, anger, politeness, and harshness, for example, or attitudes such as politeness, authoritarianism, arrogance. Thus, human language is characterized by a complex and sophisticated system in which prosody takes part.

Hudson et al. (2005) also showed that prosody plays a key role in the assessment of reading fluency. These authors present a list of prosodic aspects that should be observed during reading: vocal emphasis; proper use of ascending and descending tone; voice inflection; tone of voice appropriate to represent mental states such as excitement, sadness, fear and distrust present in narrative texts with dialogue; the pause fits within phrase boundaries; use of prepositional phrases to adequately pause within sentence boundaries; subject-verb divisions for a proper pause within sentence boundaries; the use of conjunctions to properly pause within sentence boundaries. These properties can distinguish proficient readers from non-proficient readers. Thus, a proficient reader not only decodes the written code, but also makes use of various linguistic knowledge from segmental aspects, such as word recognition, to suprasegmental issues such as intonation (ascending and descending

contours, marking the different modalities of sentences – interrogative, exclamatory, affirmative, etc., as well as relevant pragmatic aspects of the text that the reader wants to convey). In addition to vocal emphasis and voice inflection in specific parts of the text, the proficient reader draws on his knowledge of the world about the contexts in which speeches are produced for the proper use of prosodic aspects.

3. Acoustic aspects of emotions

't Hart et al. (1990) ensure that the speaker, when expressing the various utterances, more than articulating a sequence of sounds organised in limits of time, controls the intensity, duration, melody and quality of the voice in the production of sounds. Thus, over a segmental layer (which has a linguistic dimension) a suprasegmental layer (which has an expressive dimension) is launched in order to contribute to the process of meaning construction.

Then, prosody has a very relevant role in the verbal interaction process in which the different communicative intentions, attitudes and emotions of the speakers that contribute to the integral understanding of the utterance message are expressed. It is known that different attitudes of speakers – politeness, authoritarianism, doubt, uncertainty and emotions – anger, sadness, joy, etc., can also be expressed through prosody. Several studies with different approaches have addressed this relationship between prosody and speakers' attitudes and emotions (Fónagy, 1993; Pike, 1945; Wichmann, 2002).

The various communicative situations in which the speaker is inserted on a daily basis demand communicative intentions that can often be inferred by the listener, taking into account only the melodic variation of the speaker's voice: F_0, duration, speech rate, etc. Thus, the speech signal allows knowing information about the physical (age, sex/gender, etc.) and emotional condition of the speaker (Laver & Trudgill, 1979; Mozziconacci, 2002; Mozziconacci & Hermes, 1999), due to the fact that the emotions cause changes in the breathing pattern, phonation and articulation of the speaker's phonatory system, resulting from changes in the somatic nervous system and the autonomic nervous

system, thus altering the parameters of the speech acoustic signal (Banse & Scherer, 1996; Scherer, 1989; Williams & Stevens, 1972).

These alterations that occur in speech as a consequence of the speaker's affective states are investigated through acoustic analysis of the physical properties of speech in which prosodic parameters such as intensity, duration, fundamental frequency, etc., are measured. The most studied parameters in the literature have been those related to vocal fold vibration (fundamental frequency), time (speech rate and duration of utterances and pauses) and intensity (amount of energy in the speech signal, responsible for the sensation of volume).

The vast majority of studies on emotive speech postulate discrete categories for emotions, conceiving a small set of fundamental basic emotions that are characterized by showing vocal patterns, as well as very specific facial expressions. Thus, the emotions considered basic are joy, sadness, anger, fear and surprise (Ekman, 1992; Laukka, 2004; Scherer, 2003).

Among the acoustic signals analyzed for the vocal expression of emotions, a few standout aspects such as the fundamental frequency, the F_0 variation, vocal intensity and duration.

The fundamental frequency (F_0) is an acoustic correlate of the vocal fold vibration rate and is perceived as the pitch of the voice. It can be identified in the speech acoustic signal as the number of cycles of the complex wave per second or as the inverse of the period (T) of the wave (1/T) and is measured in Hertz (Hz) or semitones (St). F_0 has been shown to be very important for the expressiveness of emotions in speech, as it has behaved consistently for personality characteristics and variations in the speaker's emotional state (Scherer, 1982; Williams & Stevens, 1972). Murray and Arnott (1993) and Scherer (1984) proved that the fundamental frequency seems to be the most important acoustic parameter in the identification of emotions in speech.

Sound intensity measures the amount of energy in the speech signal, reflecting the sense of loudness better than the amplitude of the wave (Johnson, 1997). This parameter is usually measured in decibels (dB), which corresponds to a logarithmic scale.

As for duration, two parameters related to time have been shown to be useful in the characterization of the speaker's emotional states: i) the pause, which corresponds to a period in the utterance in which there is speech interruption, that can be silent or not (Oh, 2010); ii) speaker's utterance rate, which corresponds to the number of phonetic syllables that the speaker produces per second during the utterance.

Emotions such as sadness, characterized by a low degree of activation and negative intrinsic pleasure, may present relatively long pauses, as well as a large amount of hesitation in speech. This also occurs with emotions that impair speech planning, such as anxiety (Johnstone & Scherer, 2000).

Studies show that fear, anger and joy are often expressed with a higher than usual speech rate while sadness and boredom are expressed with a lower speech rate (Scherer, 2003). The literature on the vocal pattern of anger is extensive and the main results attest to an increase in the fundamental frequency, although there was no homogeneity in the F_0 values, due to the great variation, strong intensity and rapid speech rate (Banse & Scherer, 1996; Ferreira-Netto et al., 2014; Laukka, 2004; Scherer, 2003, 2005; Vassoler, 2011; Vassoler & Martins, 2013).

Sadness, in turn, presents a pattern of decreasing fundamental frequency, with few variations and weak vocal intensity (Ferreira-Netto et al., 2014; Johnstone & Scherer, 2000; Scherer, 1986; Scherer, 2003; Vassoler, 2011). Joy follows a similar pattern to anger with an increase in acoustic parameters (Johnstone & Scherer, 2000; Scherer, 2003). Scherer (2003) showed that fear, anger and joy are often expressed with a higher speech rate than usual while sadness and boredom are expressed with a lower speech rate. In addition to speech rate, pause is also an important temporal parameter in the characterization of emotive speech. Sadness, for example, can present relatively long pauses and speech hesitations, due to the low degree of activation and negative intrinsic pleasure (Scherer, 2003).

Although we have investigated the affection feeling, in order to contrast, in acoustic terms, affectionate speech and angry speech (because children generally understand affection as being contrary to hate or anger), we recognize, according to Scherer (2003), that emotions

and feelings are different things, with love/affection being a feeling and not an emotion in itself.

Although attitudes and emotions of speakers are distinct, due to the fact that these emotions are involuntary and universal and those are voluntarily controlled and dependent on the linguistic system (Aubergé, 2002; Fonagy, 1993), we emphasize that, in the written text, both can be registered through semantic expressions that indicate specific prosodic patterns.

Considering that, when reading a text, the subject acts as a speaker and presents melodic and intonation variations typical of oral language in reading aloud, it is expected that more schooled readers are more efficient in reading tasks regarding the proper use of prosodic aspects of written text, whether prompted by graphic signs, including punctuation marks, or by the semantic content through which it is possible to infer the emotions and attitudes of speakers.

4. Materials and methods

The study was approved by the Research Ethics Committee of the Federal University of Minas Gerais and is registered under number CAAE: 21000919.6.0000.5149.

The study included 45 students, 15 from the 6th year of elementary school (between ten and eleven years old), 15 from the third year of high school (between seventeen and eighteen years of age) and 15 students from the final year of their first graduation (between twenty-two and twenty-five years of age).

Three basic emotions were selected, namely, joy, anger and sadness. In addition, we also selected the affection feeling in order to contrast it with the anger.

Two target phrases ("That's what you want" and "You'll be fine") were elaborated and incorporated in small and evoke semantic contexts such as the aforementioned emotions, so that the lexical and semantic content of the text (e.g., adverbial phrases such as "screamed angrily", "said lovingly", that preceded the target phrases) guided the reader.

The sentences were also read in isolation target. Each text contained only one emotion. Each emotion occurred four times in different texts, but these texts had similar semantic content that evoked the same emotion. With this, we guarantee a sufficient amount of data for statistical analysis.

Target phrases out of context were read first. Then the participants read the texts in which the emotions were manifested. The texts were randomly arranged.

The task involved reading aloud texts with emotional content. The reading was recorded individually in an acoustically treated booth, in order to avoid incoming noise that could compromise the quality of the recordings. The acoustic signal was directly captured in the PRAAT® program, using a unidirectional microphone attached to the participant's head, positioned five centimeters lateral to the participant's mouth.

For the instrumental acoustical analysis of the target phrases, the broadband spectrogram (the fundamental frequency curve) was analyzed using the Praat 5.3.5.2 program (Boersma & Weenink, 2017). The acoustic parameters used in the study were the fundamental frequency (F_0), extracted in semitones, the intensity and the speech rate.

From the texts, only the target sentences were analyzed. They were segmented syllable by syllable, and from each of them we extracted the fundamental frequency. The measurement of F_0 included the extraction of F_0 from all syllables of the target sentences. Thus, we obtained the mean values of F_0, minimum F_0, maximum F_0, as well as the F_0 variation.

The intensity measurements for each target sentence were: maximum intensity, minimum intensity, and difference between maximum and minimum intensity.

For the analysis of the temporal aspects, we measured the total duration spent on reading the target sentence (total utterance time). The utterance rate comprised the utterance time divided by the number of phonetic syllables.

There were 30 occurrences of each emotion, considering a total of 15 participants per group multiplied by two target utterances.

The scores were subjected to statistical analysis. The non-parametric Kruskal-Wallis test (kruskal.test) was used for the data of the three investigated groups, with a significance level of 95%, with p values considered significant if $p \leq 0.05$. The nonparametric test was chosen because the data did not follow a normal distribution, which was confirmed by the D'Agostino-Pearson (K samples) and D'Agostino (k samples) normality tests.

5. Results of the Elementary School group

Table 1 shows the results found in the reading of elementary school participants regarding the mean F_0 and the F_0 variation for emotions and for the neutral form.

Table 1 – Means (and respective standard deviations (SD), in parentheses) for the F_0 and F_0 variation (in semitones) of emotions and neutral form and p values resulting from the comparison of the averages from the elementary school readers

Emotions	Mean F_0 (SD)	Mean F_0 variation (SD)
Joy	13.1 (3.9)	7.9 (2.9)
Sadness	12.8 (3.5)	7.7 (1.3)
Affection	12.8 (4.2)	5.4 (2.7)
Anger	12.7 (6.5)	9.5 (3.5)
Neutral Form	12.7 (3.8)	7.7 (2.4)
Comparison between emotions	**p-value**	**p-value**
Joy x Sadness	0.22	0.27
Joy x affection	0.31	0.37
Joy x Anger	0.57	0.98
Joy x Neutral Form	0.65	0.39
Sadness x Affection	0.83	0.18
Sadness x Anger	0.52	0.28
Sadness x Neutral Form	0.42	0.79
Affection x Anger	0.69	0.47
Affection x Neutral Form	0.61	*0.0007**
Anger x Neutral Form	0.90	0.41

Note: * = significant (p value ≤0.05).

The data presented in table 1 from the less schooled group, referring to elementary school participants, show that, in relation to the mean F_0,

there was no statistically significant difference between the different emotions, nor between the different emotions and the neutral form. However, we found that the neutral form was statistically different only from affection, the latter with less F_0 variation.

The results found for the intensity in different emotions and in the neutral form are shown in table 2.

Table 2 – Means (and respective standard deviations (SD), in parentheses) for the maximum intensity and for intensity variation (in decibels) of emotions and of the neutral form and p values resulting from the comparison of the means of readers of the elementary School

Emotions	Maximum Intensity (SD)	Mean intensity variation (SD)
Joy	70.6 (3.5)	11.5 (5.6)
Sadness	70.5 (3.5)	11.4 (4.0)
Affection	71.6 (3.0)	12.5 (3.5)
Anger	71.4 (3.7)	10.4 (3.9)
Neutral Form	68.1 (4.9)	9.9 (4.3)
Comparison between emotions	**p-value**	**p-value**
Joy x Sadness	0.89	0.28
Joy x Affection	0.23	0.66
Joy x Anger	0.25	0.28
Joy x Neutral Form	0.25	*0.0099**
Sadness x Affection	0.23	0.54
Sadness x Anger	0.17	0.95
Sadness x Neutral Form	*0.0317**	0.15
Affection x Anger	0.98	0.47
Affection x Neutral Form	*0.0037**	*0.0269**
Anger x Neutral Form	*0.0038**	0.16

Note: * = significant (p value ≤0.05).

As concerning to maximum intensity, we found that the neutral form was statistically different from anger, affection and sadness but not from joy, as shown in table 2. As for the variation in intensity, it appears that the neutral form was statistically different from joy and affection, with less intensity variation for the neutral form.

Based on the results found for the intensity and for variation of the intensity of emotions and the neutral form in the reading from

elementary school participants, the following hypothesis was outlined: the difference in intensity between the neutral form and the emotions anger, affection and sadness may have been due to the fact that, for the target sentences in the neutral form, the participants, in general, attributed less intensity, perhaps due to the slower decoding process, considering that the target sentences in the neutral form (outside of context) were first presented to the participants, being their first reading. This hypothesis would justify the fact that this group did not differentiate the sadness from joy and from anger, for example, which suggests that the difference in intensity of the neutral form with the different emotions was not due to conscious adjustments of acoustic parameters in order to characterize the different emotions of speakers.

Table 3 shows the results found in the ANOVA statistical test by the Kruskal Wallis when comparing the average speech rate of different emotions and neutral form in the reading of elementary school participants.

Table 3 – Means (and respective standard deviations (SD), in parentheses) for the speech rate of emotions and of the neutral form and p values resulting from the comparison of means of the Elementary School readers

Emotions	Mean Speech rate (SD)
Joy	5.0 (1.1)
Sadness	5.0 (0.9)
affection	5.2 (1.0)
Anger	4.9 (0.9)
Neutral Form	4.6 (1.0)
Comparison between emotions	**p-value**
Joy x Sadness	0.94
Joy x affection	0.72
Joy x Anger	0.44
Joy x Neutral Form	*0.0202**
Sadness x Affection	0.78
Sadness x Anger	0.39
Sadness x Neutral Form	*0.0433**
Affection x Anger	0.27
Affection x Neutral Form	0.56
Anger x Neutral Form	*0.0312**

Note: * = significant (p value ≤0.05).

With regard to the speech rate, significant differences were found between the neutral form, with the lowest mean speech rate, and the emotions joy, sadness and anger, with higher speech rate means. This data also corroborates the previously mentioned hypothesis, that the slower decoding for the sentences of the neutral form might have resulted in little variation of F_0 and in low intensity.

The results found allow some considerations to be made: as for the prosodic parameters (F_0, intensity and duration), the elementary school group did not differentiate between happiness and sadness, nor between joy and affection, or between joy and neutrality, or between sadness and affection, or between sadness and anger. This is not expected, since, from a prosodic-acoustic point of view, for sadness, lower F_0 and intensity values and a lower elocution rate are expected (Ferreira-Netto et al., 2014; Martins, 2017). Thus, sadness should differ acoustically from joy and anger, which are characterised by higher intensity and F_0 values. On the other hand, the elementary school group differentiated the neutral form from sadness, affection and anger, with lower values of F_0, intensity and elocution rate for the neutral form. This fact is strong evidence that the acoustic-prosodic differences in the reading of target sentences in neutral form had lower F_0 and intensity values because they were presented before the texts (in which the target sentences were inserted in contexts) for reading, which required more time to decode the sentence causing a less expressive reading, with little variation in F_0 and vocal intensity.

6. High School Group Results

The mean values found in the reading of high school participants for the means of F_0 and for the F_0 variation of emotions and in a neutral form are presented in table 4.

Table 4 – Means (and respective standard deviations (SD), in parentheses) for the F_0 and F_0 variation (in semitones) of emotions and neutral form and p values resulting from the comparison of the averages from the high school readers

Emotions	Mean F_0 (SD)	Mean F_0 variation (SD)
Joy	9.6 (6.6)	10.4 (4.6)
Sadness	7.9 (5.9)	7.3 (4.3)
Affection	9.0 (6.4)	10.3 (4.2)
Anger	9.8 (6.9)	9.3 (4.3)
Neutral Form	8.5 (6.7)	8.3 (5.0)
Comparison between emotions	**p-value**	**p-value**
Joy x Sadness	*0.0015**	*0.0001**
Joy x Affection	0.54	0.95
Joy x Anger	0.79	0.33
Joy x Neutral Form	0.37	0.66
Sadness x Affection	*0.0364**	*0.0002**
Sadness x Anger	*0.0004**	*0.0037**
Sadness x Neutral Form	*0.0382**	0.78
Affection x Anger	0.41	0.09
Affection x Neutral Form	0.69	0.71
Anger x Neutral Form	0.09	0.24

Note: * = significant (p value ≤0.05).

As we can see in the results presented in Table 4, regarding F_0, high school participants acoustically differentiated sadness from other emotions, as well as from the neutral form. We noticed that joy and anger had higher F_0 means and greater F_0 variation than the sadness. Regarding F_0, sadness had significantly lower means than the joy, anger, affection and neutral form. The F_0 means of anger were not statistically different from the means of joy, affection, or neutral form. Thus, we found that, with regard to the mean F_0 variation, there were no significant differences between joy, anger, affection and the neutral form, so that, when it comes to the investigation of emotions in reading aloud, parameters other than F_0 seem necessary.

The data shown in table 5 refer to the maximum intensity and the variation in intensity in emotions and in the neutral form.

Table 5 – Means (and respective standard deviations (SD), in parentheses) for the maximum intensity and for intensity variation (in decibels) of emotions and of the neutral form and p values resulting from the comparison of the means of readers of the High school

Emotions	Maximum Intensity (SD)	Mean intensity variation (SD)
Joy	73.8 (3.8)	12.2 (3.7)
Sadness	69.8 (3.9)	10 (3.1)
Affection	71.8 (4.2)	11.8 (3.0)
Anger	76 (4.1)	14.5 (3.7)
Neutral Form	72.3 (4.2)	11.4 (3.5)
Comparison between emotions	**p-value**	**p-value**
Joy x Sadness	*< 0.001**	*0.0112**
Joy x Affection	*0.0205**	0.72
Joy x Anger	*< 0.001**	*0.0053**
Joy x Neutral Form	0.74	*0.0015**
Sadness x Affection	*0.0458**	0.43
Sadness x Anger	*< 0.001**	*< 0.001**
Sadness x Neutral Form	*0.0006**	0.13
Affection x Anger	*< 0.001**	*0.0002**
Affection x Neutral Form	0.09	0.42
Anger x Neutral Form	*< 0.001**	*0.0071**

Note: * = significant (p value ≤0.05).

With regard to maximum intensity, it was found that all emotions were statistically different from each other, as well as from the neutral form, with the exception of affection and joy, which did not differ from the neutral form in terms of intensity. Joy and anger had higher means of intensity variation and sadness had lower means of intensity variation. Compared to anger, joy and sadness, affection and neutral form had intermediate means of intensity, so to speak: not as high as the mean for joy and anger, not as low as the mean for sadness. The data presented in table 5 also reveal that, although anger and joy have higher intensity means than the mean of other emotions, they are different from each other, with anger being characterized by greater intensity than joy, being that this difference significant according to the Kruskal Wallis ANOVA test.

Regarding the intensity variation, the data in table 5 show that the intensity variation was statistically higher for anger and statistically lower for sadness compared to other emotions and to the neutral form.

The intensity variation was similar for joy, affection and neutral form. The statistical test showed that the mean of intensity variation in sadness was significantly lower than the mean of anger and joy, but it did not differ from the mean of affection and the neutral form. The variation in intensity was significantly higher for anger than for other emotions and for the neutral form. There was no significant difference between joy and affection in terms of intensity variation.

Table 6 presents the data found for the speech rate of emotions and neutral form in the reading of high school participants.

Table 6 – Means (and respective standard deviations (SD), in parentheses) for the F_0 and F_0 variation (in semitones) of emotions and neutral form and p values resulting from the comparison of the averages from the high school readers

Emotions	Mean Speech rate (SD)
Joy	6.0 (1.2)
Sadness	5.8 (0.9)
Affection	5.9 (1.2)
Anger	6.0 (1.0)
Neutral Form	5.6 (0.9)
Comparison between emotions	**p-value**
Joy x Sadness	0.28
Joy x affection	0.82
Joy x Anger	0.82
Joy x Neutral Form	*0.0295**
Sadness x Affection	0.30
Sadness x Anger	0.44
Sadness x Neutral Form	0.17
Affection x Anger	0.79
Affection x Neutral Form	0.09
Anger x Neutral Form	*0.0486**

Note: * = significant (p value ≤0.05).

Regarding the speech rate, statistically significant differences were found between the means of the neutral form and joy, with a higher speech rate for joy. The neutral form also differed significantly, in terms of speech rate, from anger, with a higher speech rate for anger.

Considering the analysis of fundamental frequency, intensity and speech rate (presented in tables 4, 5 and 6) we can suggest that the high

school group differentiated joy from other emotions and the neutral form; there was a difference also in sadness from other emotions and from the neutral form; also from anger compared to other emotions and to the neutral form. This group did not differentiate affection from the neutral form. The target sentences occurred in higher frequency ranges in the reading of texts which emotional content was joy, affection and anger and in lower frequency ranges in texts which emotional content was sadness. However, F_0 was significantly higher for joy and anger compared to affection. The intensity was statistically higher for anger, joy and affection. However, compared to joy and anger, affection had a significantly lower average of intensity.

7. Results of the Higher Education group

Table 7 shows the results found for F_0 and for the F_0 variation of emotions and in a neutral form in the readings of the group of higher education participants.

Table 7 – Means (and respective standard deviations (SD), in parentheses) for the F_0 and F_0 variation (in semitones) of emotions and neutral form and p values resulting from the comparison of the averages from the Higher School readers

Emotions	Mean F_0 (SD)	Mean F_0 variation (SD)
Joy	10.4 (5.0)	8.2 (2.6)
Sadness	8.8 (4.6)	6.8 (3.2)
Affection	9.9 (5.3)	8.4 (3.2)
Anger	11.1 (5.0)	9.4 (3.1)
Neutral Form	10.2 (4.6)	7.5 (2.8)
Comparison between emotions	**p-value**	**p-value**
Joy x Sadness	*0.0001**	*0.0059**
Joy x Affection	0.20	0.64
Joy x Anger	0.41	*0.0358**
Joy x Neutral Form	0.60	0.09
Sadness x Affection	*0.0175**	*0.0014**
Sadness x Anger	*< 0.0001**	*< 0.0001**
Sadness x Neutral Form	*0.0184**	*0.0177**
Affection x Anger	0.06	*0.0224**
Affection x Neutral Form	0.51	0.16
Anger x Neutral Form	*0.0005**	*0.0015**

Note: * = significant (p value ≤0.05).

Regarding F_0, the data from the group of higher education participants showed statistically significant differences between different emotions, as well as between different emotions and the neutral form. It was found that joy had higher F_0 means and higher F_0 variation than sadness; the F_0 variation for joy was also higher than the F_0 variation for anger. The mean F_0 values and the mean F_0 variation of sadness are inferior to those of joy, anger and neutral form. Compared to affection, sadness has a smaller F_0 mean and smaller mean F_0 variation. Anger had a higher F_0 mean and higher mean F_0 variation, compared to the neutral form and, in relation to affection, it shows a higher F_0 mean. The neutral form did not differ statistically from affection nor from joy in relation to F_0.

The data regarding the maximum intensity and the variation of intensity in emotions and in the neutral form are shown in table 8.

Table 8 – Means (and respective standard deviations (SD), in parentheses) for the maximum intensity and for intensity variation (in decibels) of emotions and of the neutral form and p values resulting from the comparison of the means of readers of the Higher Education readers

Emotions	Maximum Intensity (SD)	Mean intensity variation (SD)
Joy	73.7 (5.9)	13.1 (3.6)
Sadness	69.6 (4.3)	8.4 (2.9)
Affection	71.1 (4.4)	11.9 (2.7)
Anger	75.7 (6.2)	14.3 (4.1)
Neutral Form	72 (4.9)	12.6 (3.6)
Comparison between emotions	**p-value**	**p-value**
Joy x Sadness	*< 0.001**	*< 0.001**
Joy x affection	*0.0004**	*0.0186**
Joy x Anger	*0.0063**	*0.0105**
Joy x Neutral Form	*0.0333**	0.47
Sadness x Affection	*0.0056**	*< 0.001**
Sadness x Anger	*< 0.001**	*< 0.001**
Sadness x Neutral Form	*< 0.001**	*0.0011**
Affection x Anger	*0.0001**	*< 0.001**
Affection x Neutral Form	*0.0003**	0.23
Anger x Neutral Form	*< 0.001**	*0.0008**

Note: * = significant (p value ≤0.05).

With regard to intensity, it was observed that joy differed statistically, with a higher mean intensity, from affection, from sadness and from the neutral form, but in relation to anger, joy had a significantly lower average intensity. The data presented in table 8 also reveals that sadness differed statistically, in terms of maximum intensity, from all emotions, as well as from the neutral form, with a lower average intensity.

For anger, significantly higher averages of maximum intensity were found, compared to those found for other emotions and for the neutral form.

The neutral form had averages of maximum intensity significantly higher than the averages for sadness and affection, but compared to anger and to joy, the neutral form had averages of maximum intensity significantly lower.

In relation to intensity variation, the neutral form had mean values similar to those of joy and affection, as the statistical test did not show significant differences between the neutral form and joy nor between the neutral form and affection. However, joy had a significantly higher mean of intensity variation than the means found for sadness and for affection. Anger had a significantly higher mean of intensity variation than the other emotions and the neutral form. Sadness had the lowest mean of intensity variation.

Table 9 shows the results found for the speech rate of emotions and neutral form in the readings of higher education participants.

Table 9 – Means (and respective standard deviations (SD), in parentheses) for of the speech rate of emotions and of the neutral form and p values resulting from the comparison of the means of the Higher Education readers

Emotions	Mean Speech rate (SD)
Joy	6.4 (1.0)
Sadness	5.7 (0.9)
Affection	6.0 (0.8)
Anger	6.3 (1.2)
Neutral Form	5.9 (0.8)
Comparison between emotions	**p-value**
Joy x Sadness	*0.0011**
Joy x affection	0.12
Joy x Anger	0.84
Joy x Neutral Form	*0.0092**
Sadness x Affection	*0.0089**
Sadness x Anger	*0.0314**
Sadness x Neutral Form	0.24
Affection x Anger	*0.0187**
Affection x Neutral Form	0.78
Anger x Neutral Form	*0.0095**

Note: * = significant (p value ≤0.05).

With regard to speech rate, joy and anger had a significantly higher mean speech rate than sadness and the neutral form. Anger had a significantly higher speech rate than affection, but affection did not differ from joy. Affection had a significantly higher mean speech rate than sadness. There was no statistically significant difference between anger and joy regarding the speech rate, nor between sadness and the neutral form. There was also no significant difference between affection and neutral form.

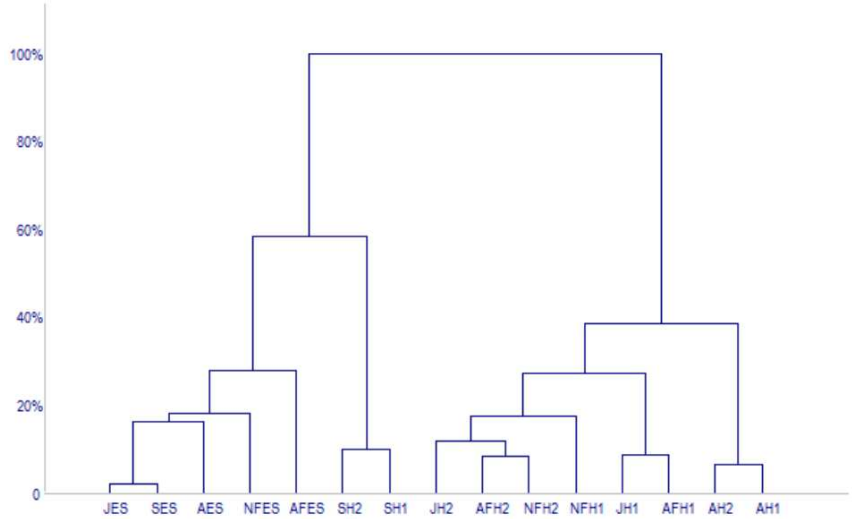
The data found for the fundamental frequency, for the intensity and for the speech rate, presented in tables 7, 8 and 9, respectively, showed that the higher education group differentiated joy from other emotions and the neutral way; this group differentiated sadness from other emotions and from the neutral form; differentiated anger from other emotions and from the neutral form. This group differentiated the affection from the neutral form only by the maximum intensity. The differences between the emotions we refer to are shown to be statistically significant for at least one of the four acoustics parameters investigated.

The target sentences occurred in higher frequency ranges in the reading of texts which emotional content was joy, affection and anger and in lower frequency ranges in texts which emotional content was sadness. However, F_0 was statistically higher for joy and anger compared to affection. The intensity was statistically higher for anger, joy and affection. However, compared to joy and anger, affection had a significantly lower mean intensity.

8. Discussion

In order to test the investigated variables, a Cluster's multivariate analysis was performed using the Ward method. The cluster analysis (figure 1) showed the formation of two groups: on the left margin we found the emotions performed by elementary school students and, on the right margin, we found the emotions performed by students of high school and by the participants of higher school, which shows that the processing of target reading under the scope of the investigated emotions was different between the less schooled group and the more schooled groups.

Figure 1 – Dendrogram performed by Ward's method based on data from the three investigated groups (Tables 1 to 9)



On the horizontal axis, it is possible to verify the variables of education level and expression of emotions grouped according to the evaluated acoustic parameters. The vertical axis represents the distance between the grouped variables. The smaller the vertical trace, the greater the similarity between the grouped variables or group of variables. Note: The first letters the letters J, A, S, AF and NF represent the emotions joy, anger, sadness, affection and the neutral form, respectively; the letters ES, H1 and H2, following the initials of emotions, represent the level of education (elementary school, high school and higher education, respectively).

For the more schooled groups, whose participants are from high school and higher education, we observed that anger presents less similarity with the other emotions, as shown by the Cluster's analysis carried out individually by group (figures 2, 3 and 4). For the higher education group, the greatest distance was verified between anger and sadness and the smallest distance between affection and neutral form. For this group, sadness and anger were less similar to the other emotions and there was greater similarity between joy, affection and the neutral form. For the high school group, anger presents less similarity with the other emotions and there was an identification between sadness and the neutral form and between joy and affection. For the elementary school class, in turn, we noticed that the neutral form showed greater distance from emotions and there was identification between joy and sadness, as evidenced in the groupings of figures 2, 3 and 4.

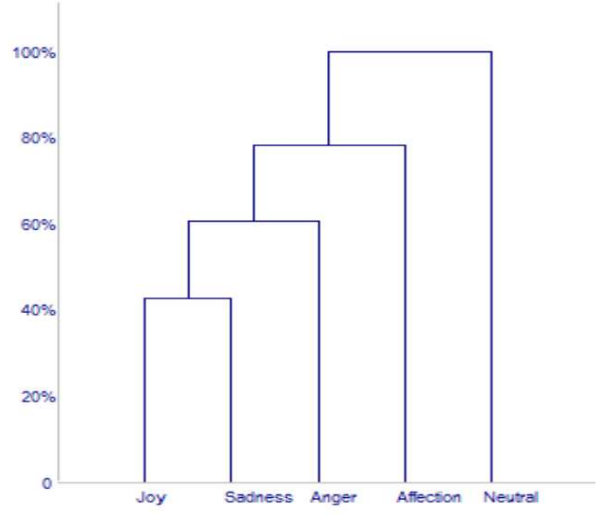


Figure 2 – Dendrogram performed by the Euclidean method from the data in tables 1,2 and 3 - (Elementary School)

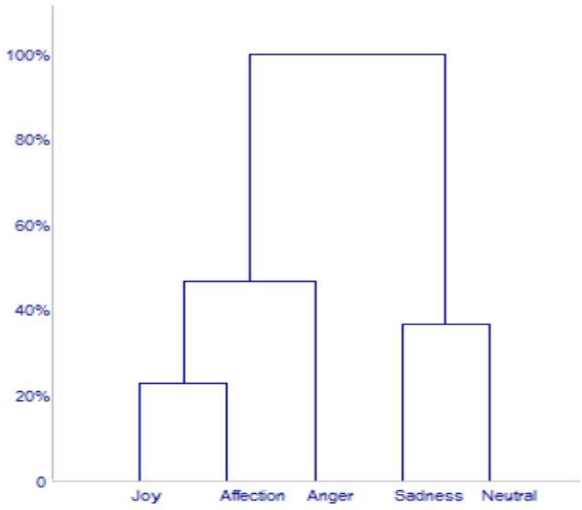


Figure 3 – Dendrogram performed by the Euclidean method from the data in tables 4, 5 and 6 (High School)

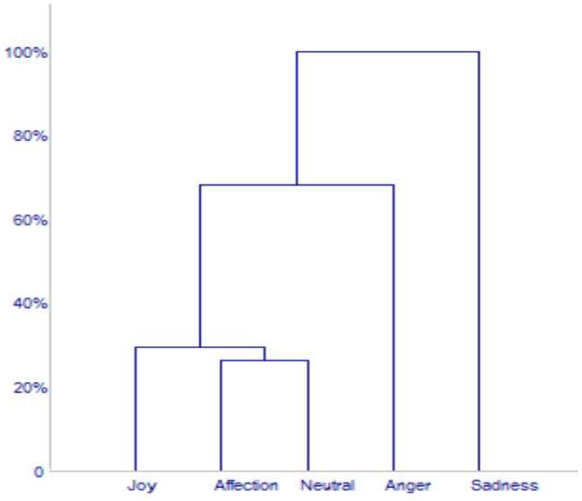
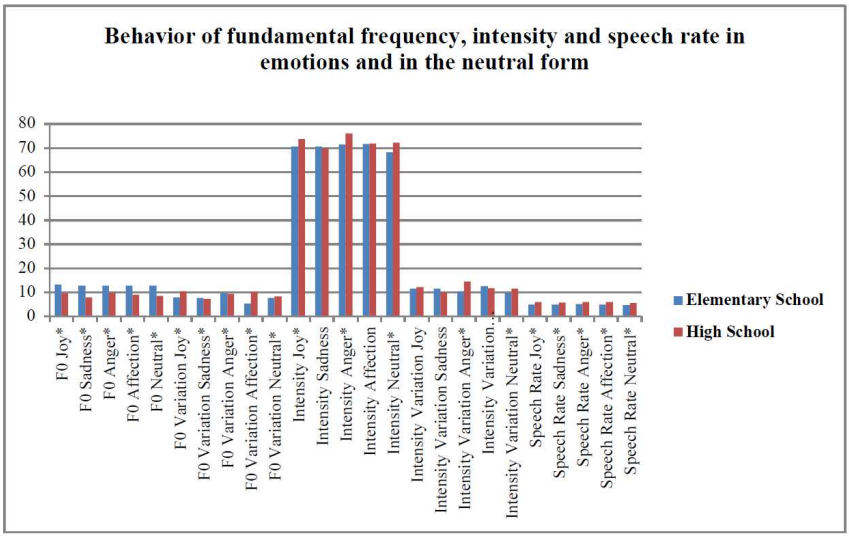


Figure 4 – Dendrogram performed by the Euclidean method from the data in tables 7,8 and 9 (Higher Education)

Qualitatively, the more schooled groups (high school and higher education) showed a different performance, regarding the marking of pragmatic aspects in reading aloud, from the performance of the less schooled group (elementary school), as shown by the Mann-Whitney statistical test for the comparison across groups. Results are shown in graphs 1, 2 and 3.

Graph 1 – Comparison between the elementary school group and the high school group

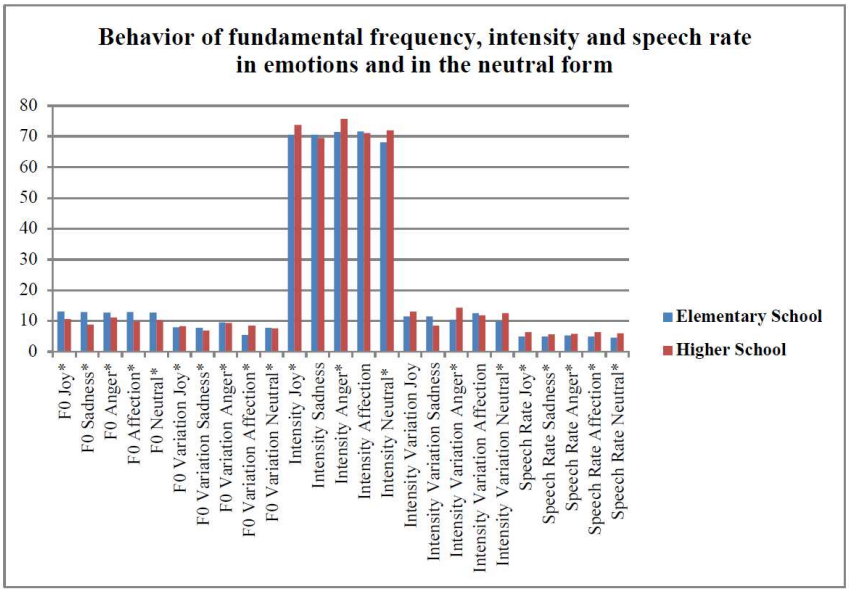


Note: * = significant (p value ≤0.05).

The Mann-Whitney statistical test found statistically significant differences in the comparison of F_0 values, F_0 variation and speech rate, for all emotions and for the neutral form, between the elementary school group and the high school group and between the elementary school group and the high school group. Regarding the maximum intensity, for sadness and affection, there was no significant difference between the elementary school group and the high school group. The high school participants decreased the vocal intensity for sadness and affection. Similarly, there was no significant difference between the elementary school group and the high school group in terms of variation of intensity in sadness and affection.

Still in relation to the variation of intensity, there was no statistically significant difference between the groups for joy and affection, as shown in the data presented in graphs 1 to 3.

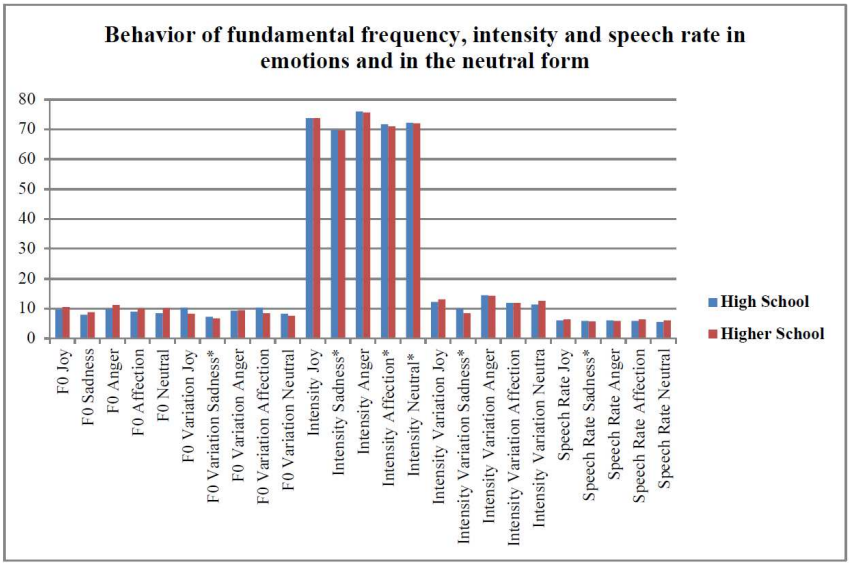
Graph 2 – Comparison between the elementary school group and the higher education group



Note: * = significant (p value ≤0.05).

Graph 2 shows that, between the elementary school group and the higher education group, there was no difference regarding the intensity in the expression of sadness and affection. There was also no difference between the groups regarding the intensity variation in the expression of joy and affection.

Graph 3 – Comparison between the high school group and the higher education group



Note: * = significant (p value ≤0.05).

Graph 3 shows that, in the comparison between the high school group and the higher education group, the Mann-Whitney statistical test showed a significant statistical difference between the groups in the expression of emotions. However, we emphasize that according to the Mann-Whitney test, there was no significant difference between the high school and higher education groups regarding intensity, nor regarding the variation of intensity in the expression of sadness. There was also no statistically significant difference between these groups regarding the variation of intensity in the expression of affection.

The F_0 values found for the target sentences under the scope of anger, joy, sadness, affection, as well as in a neutral form, showed that, for the high school group and for the higher education group, when target sentences occurred under the scope of joy and anger, they were chanted (were read) with higher frequency ranges and with greater intensity; when the target sentences occurred under the scope of sadness, they were characterized by lower F_0 and intensity values. These data are evidence that the prosodic planning during the reading of sentences with emotional content, produced by the groups analyzed

in this study, reveals a progression in the development of reading skills, such as the processing of higher-level information, at the semantic and pragmatic level, with the advancement of schooling.

Some studies on prosodic aspects of attitudes and emotions of speakers have suggested that acoustic parameters such as F_0, duration and intensity are adjusted depending on the attitude and/or emotion that the speaker wants to imprint. By comparing three basic emotions, namely, joy, anger and sadness and the feeling of affection, it was possible to quantitatively verify how such adjustments occur. The results found for the emotions investigated here are in line with the results obtained by Ferreira-Netto et al. (2014), Martins (2017) and Vassoler (2011).

Our hypothesis was that more schooled readers would tend to prosodically mark pragmatic issues of written text in reading aloud more adequately, compared to less schooled readers. Therefore, our data showed that, in fact, readers at an early stage of schooling are less skilled in expressive reading, that is, in marking pragmatic aspects of the written text when reading aloud.

Conclusion

The results found in this study have implications for the teaching of reading and textual comprehension, as the student, when reading a text, needs to be able to recognize pragmatic issues such as emotion (e.g., sadness, anger, joy, etc.) and attitudes of speakers (e.g., politeness, irony, sarcasm, etc.) and, in case of reading aloud, marked by means of acoustic parameters (e.g., F_0 settings, intensity, duration, etc.) so that the listener can also understand the message being read. Therefore, teaching reading skills must involve exploring pragmatic aspects of the text, as well as the impact that such aspects have on text comprehension (Cagliari, 1992).

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Conflict of interests

We declare that we have no potential conflict of interest in this study.

Authors contributions

We, Alcione de Jesus Santos, Rui Rothe-Neves, Vera Pacheco and Virgínia Silveira Baldow, declare, for all due purposes, that we do not have any potential conflict of interest in this study. We all participated in study conceptualization, methodology, study design, formal data analysis, statistical data analysis, project administration, project supervision, data collection, data generation, data validation and editing.

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