Phonological Phrase Boundaries Restrictions in Lexical Access by BP Adult Speakers

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Abstract

This study investigates the role of prosodic unit boundaries in on-line lexical access by Brazilian Portuguese adult speakers. Two types of prosodic constituents are considered: prosodic words (ω) and phonological phrases (ϕ). Motivated by French experimental results, we proposed two experiments in order to examine on-line lexical access in auditory sentences, considering that prosodic unit boundaries could help the listener to identify morphological word boundaries more easily. In a word detection task, participants were requested to press a button as soon as they heard the target word previously shown on a computer screen. The results suggest that phonological phrase boundaries were relevant cues in the constraint of lexical access, inhibiting the activation of lexical competitors whereas prosodic word boundaries were not.

Index Terms: prosodic boundaries, on-line lexical access, Brazilian Portuguese.

1. Introduction

We investigated the role of prosodic constituent boundaries in on-line lexical access by adult speakers of Brazilian Portuguese (henceforth, BP). It is assumed that speech is organized in a hierarchy of prosodic constituents that may relate to constituents of other components of grammar [11]. Although this is not necessarily a one-to-one relationship, prosodic constituents such as prosodic words and phonological phrases may be regularly mapped into morphological words and certain syntactic units, respectively.

Listeners spontaneously seem to notice continuous speech as being organized into prosodic units. Some experimental evidence supports that listeners use intonational phrase and phonological phrase boundaries to constrain on-line syntactic analysis (see, for the former, [4, 13]; for the latter, see [7, 8, 10, 14]).

Concerning lexical access, word recognition models propose that several words are activated at the same time, competing until the phoneme information is enough to inhibit the activation of competitor words and constrain the access to the target word. In addition to this kind of information, some models assume that non-lexical cues may be available, helping listeners in the processes of lexical segmentation and word recognition (e.g., [6]). A French experimental study ([2], see next section) supports these assumptions. Its results showed that phonological phrase boundaries can constrain lexical access by French adult native speakers. Unlike prosodic word boundaries, those ones allow the listener to infer faster the end of the word, facilitating lexical access.

As far as we know, there are no studies investigating prosodic constraints in lexical access by BP native speakers. Moreover, the intonation pattern in declarative utterances seems to be different between BP and French. In BP, there is a moderate continuous drop in pitch over the entire sentence [5, 9] and, as evidenced in our analyses, the direction of the pitch contour across a prosodic word boundary may vary (ascending or descending). In contrast, French shows a rising pattern for pitch contour in the same place [2]. As regards phonological phrase boundaries, both languages seem to have similar patterns with a falling pitch [3, 9]. Thus, it would be interesting to investigate the effect of these prosodic unit boundaries on lexical access by BP listeners. Based on the French study, we manipulated the same variables and proposed two experiments in order to verify the role of phonological phrase boundaries in BP sentences, compared to prosodic word boundaries.

2. French language evidence

The authors intended to examine on-line lexical access in French auditory sentences, considering that prosodic unit boundaries could help the listener to indentify morphological word boundaries more easily. They manipulated two types of sentences (with and without local ambiguity) and two types of boundaries (of prosodic word and of phonological phrase).

In the Prosodic Word Condition, they investigated the effect of local lexical ambiguity within a phonological phrase, over the boundary between two prosodic words:

(1) Le livre racontait l'histoire [d'un **chat** ω **grin**cheux] ϕ qui avait mordu un facteur. (*chagrin*)
(The book told the story of a grumpy cat who had bitten a postman. / sorrow)

(2) Le livre racontait l'histoire [d'un **chat** ω **d**rogué] ϕ qui dormait tout le temps. (**chad*)
(The book told the story of a doped cat that slept all day long.)

There was a test sentence with local ambiguity (...***chat grin****cheux*...), in which *chat* and *chagrin*, two possible words in French, compete for activation and an unambiguous control sentence (...***chat d****rogué*...), in which the sequence *chad**, for not being a possible French word, does not compete with *chat*.

In the Phonological Phrase Condition, the effect of local lexical ambiguity was tested over the boundary between two adjacent phonological phrases:

(3) D'après ma soeur [le gros **chat**] ϕ [**grim**pait aux arbres] ϕ (*chagrin*)
(According to my sister, the big cat climbed the trees. / sorrow)

(4) D'après ma soeur, [le gros **chat**] ϕ [**d**ressait l'oreille] ϕ (**chad*)
(According to my sister, the big cat pricked up his ears.)

Again, there was a test sentence, in which the ambiguity between *chat* and *chagrin* spans a phonological phrase boundary and a control sentence, in which *chat* does not compete with **chad*.

The experiment consisted of a word detection task: subjects were requested to press a button as soon as they heard the target word previously shown on a computer screen, e.g. CHAT. It was predicted that in situations of ambiguity, in which the competitor word would be activated, lexical access would be delayed and, consequently, reaction times would be longer than those from the situation without ambiguity.

In the Prosodic Word Condition, reaction times were significantly higher in the ambiguous than in the non-ambiguous situation, suggesting that the boundary between prosodic words was not relevant to constrain the activation of other lexical items immediately, i.e., this type of boundary was not able to delimit the end of the word *chat* and finish the search for other words beginning with ['ʃa]. On the other hand, there was no significant difference between reaction times of ambiguous and non-ambiguous sentences in the Phonological Phrase Condition. According to the authors, this result suggests that the competitor word has not been activated. They also note that mean reaction times in this condition were shorter than those from the Prosodic Word Condition, indicating that, in French, phonological phrase boundaries allow adults to decide on-line about which lexical candidates are valid and to infer faster the end of morphological words.

3. Experiments in Brazilian Portuguese

Based on the French findings, we sought to investigate whether BP adult speakers were also sensitive to prosodic unit boundaries and whether these boundaries were relevant to on-line lexical access. As we have mentioned, French shows, in general, a rising pitch contour across a prosodic word boundary, whereas BP shows a continuous drop of the pitch over the sentence and the direction of the pitch contour in prosodic word boundaries may be either ascending or descending . Based on this difference, we intended to know if BP speakers would behave differently from the French ones in word monitoring tasks. Manipulating the same variables, we proposed two psycholinguistic experiments. The first experiment examined the effect of local ambiguity (gol/golfe) between two prosodic words [gol ω final], within a same phonological phrase. The second examined the same local ambiguity spanning the boundary between two phonological phrases: […gol] ϕ [ficou…].

3.1. Experiment 1: prosodic word boundaries

As in the French results, it could be that prosodic word boundaries were not strong enough to inhibit the activation of other candidate words, but we did not discard, however, the possibility that lexical access could occur within the domain of this constituent. If no acoustic/prosodic information in prosodic word boundaries could inhibit the local ambiguity effect, reaction times would be expected to be higher in the ambiguous than in the non-ambiguous condition.

3.1.1. Method

Participants

Twelve native speakers of BP took part in this experimental activity. Three additional subjects were excluded from the final analyses: two for technical reasons and one for presenting very slow reaction times compared to mean.

Materials

Ten pairs of experimental sentences were constructed in such a way that, within each pair, one member was a test and the other member was a control. The test sentence contained a phrase with local ambiguity, such as [**gol** ω **fi**nal], in which the string *golfe*, for corresponding to a possible word in BP, competes with *gol*. The control sentence, on the other hand, contained a phrase without local ambiguity, such as [**gol** ω **r**oubado], in which there was no competitor, since no BP word begins with the string *['gowr...].

(5) O jornalista citou [o **gol** ω **fi**nal] ϕ marcado por Ronaldo nesse jogo. (golfe)
(The journalist quoted the final goal scored by Ronaldo in the game. / golf)

(6) O jornalista citou [o **gol** ω **r**oubado] ϕ com que o time ganhou a Copa. (*golr...)
(The journalist quoted the illegal goal with which the team won the Cup.)

In each pair, the sentences had the same preamble and the same target word, as can be seen in the pair (5) and (6), in which both control and test sentences have "o jornalista citou" as preamble and "gol" as target word.

In addition to the twenty experimental sentences, thirty distractor sentences were constructed: eight containing the requested target word, eight not containing the target word nor even a syllable resembling it and, moreover, fourteen with one of the words having a internal syllable homophonous to the target word (target: BAR, homophonous syllable: emBARcar). In all experimental and distractor sentences, the target word was always one of the following monosyllables: *gol, bar, nó, fé, pó, rã, lã*.

A native speaker of BP, naive as to the aims of the experiment, read the sentences with a natural intonation. We analyzed the pitch contour across prosodic word boundaries [1] and compared with French data. BP sentences showed a mixed pattern, with 58% presenting a falling pitch contour (11 out of 19 sentences), whereas French revealed a more stable pattern, with 84% of the sentences presenting a rising contour (27 out of 32 sentences).

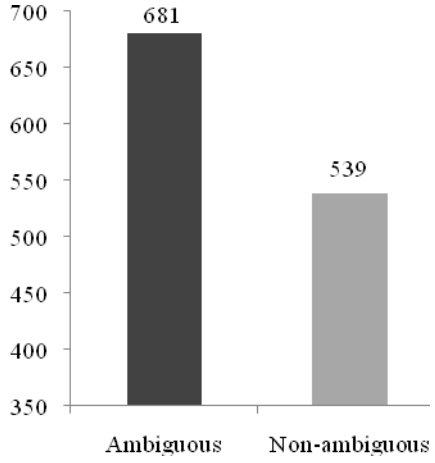
Two blocks were constructed, each one with thirty distractor and ten experimental sentences. Each block contained five test and five control sentences, distributed in such a way that each member of a given pair were in a different block. By testing participants in different blocks, we sought to avoid that they had access to two sentences with the same preamble, which could make the target word predictable, possibly interfering in the reaction times.

Procedure

Participants were tested individually and before the experiment they received five practice trials. The target word (e.g., BAR) was displayed in the center of a computer screen for 1s, after the appearance of a fixation cross for 0.5s. Then, the screen was left blank for 1s and a sentence previously recorded in audio was presented. The trial ended after the auditory presentation and a new trial began immediately. The stimuli were randomly presented and the whole procedure was managed by the Presentation software [12]. In a word monitoring task, participants were requested to press a button as faster as they could, as soon as they discriminated the target word in the auditory stimuli. Reaction times were measured from the onset of the target word.

3.1.2. Results

Graphic 1 below shows mean reaction times in test and control conditions. The test sentences contained a local ambiguity overlapping prosodic word boundaries: [gol ω final]. The control sentences did not contain such ambiguity: [gol ω roubado].



Graphic 1*: Prosodic Word Condition: Mean reaction time – ambiguous x non-ambiguous*

There was a difference of 142ms between the mean reaction times of each condition (ambiguous vs. non-ambiguous). The mean in the ambiguous condition was 26.34% higher than in the non-ambiguous one and this difference was statistically significant (681ms. vs. 539ms, $t(11)= 2.78$, $p<0.02$). Thus, the effect of local ambiguity overlapping prosodic word boundaries was significant, since the participants took longer to identify the target word in sentences in which there was a potentially competitor word (ambiguous condition) than in sentences in which there was no possible competitor word available (non-ambiguous condition). This result suggests that, as in French, the prosodic information present at prosodic word boundaries was not able to inhibit the activation of lexical competitors. Even though BP has a different pitch contour pattern across prosodic word boundaries compared with French, we had similar results. This finding supports the hypothesis that, as in French, such boundaries are not a consistent cue to constrain on-line lexical access in BP.

3.2. Experiment 2: phonological phrase boundaries

We hypothesized that, as in French, phonological phrase boundaries would be exploited on-line by BP adult speakers to constrain lexical access. In contrast to prosodic word boundaries (cf. previous section), they would be able to inhibit the activation of other candidate words. If the acoustic/prosodic information at phonological phrase boundaries is able to inhibit the local ambiguity effect, we expect no significant difference between the reaction times of the ambiguous and of the non-ambiguous condition.

3.2.1. Method

Participants
Fourteen native speakers of BP took part in this experimental activity. Three additional subjects were excluded from the final analyses: two for presenting very slow reaction times compared to mean and one for responding to the task just in two of the trials.

Materials and procedure
Ten pairs of experimental sentences were constructed following the same criteria of the experiment 1. However, the lexical ambiguity which was created within a phonological phrase (between prosodic words) now overlaps its boundary. In each pair, one member was a test and the other member was a control sentence. The test sentence contained a phrase with local ambiguity, such as [...**gol**] ϕ [**fi**cou marcado], in which the string *golfe*, for corresponding to a possible word in BP, competes with *gol* for activation. The control sentence, on the other hand, contained a phrase without local ambiguity, such as [...**gol**] ϕ [**s**erá anulado], in which there was no competitor word, since no BP word begins with the string *['gows...].

(7) O jornalista disse [que o **gol**] ϕ [**fi**cou marcado] ϕ na história do futebol. (golfe)
(The journalist said that the goal marked the history of soccer. / golf)

(8) O jornalista disse [que o **gol**] ϕ [**s**erá anulado] ϕ por decisão do juiz. (*go[w]s...)
(The journalist said that the goal will be annulled by decision of the referee.)

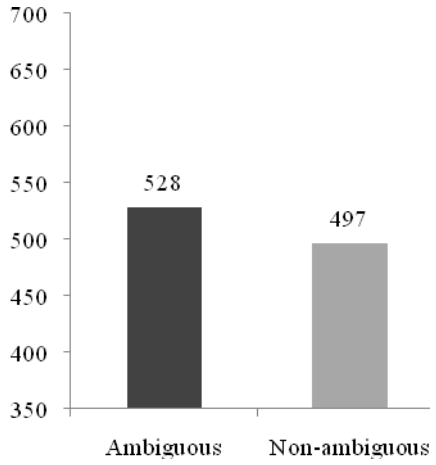
As in the first experiment, there were thirty distractor sentences: ten containing the target word, ten with one of the words having a internal syllable homophonous to the target word and ten containing neither the target word nor even a syllable similar to its phonetic sequence. The target word was always one of the following monosyllables, "*bar, fã, fé, gol, lã, pá, pó, ré, sal, rã*", in all the sentences, which were read by the same speaker of the experiment 1 and divided in such a way that each member of a given pair was in a different block.

The whole experimental procedure was identical to the Experiment 1.

3.2.2. Results

Graphic 2 shows mean reaction times in test [...gol] ϕ [ficou...] and control [...gol] ϕ [será...] conditions. The test sentences contained a lexical local ambiguity at the boundary between two phonological phrases and the control sentences did not contain such ambiguity.

There was a difference of 31ms between the mean reaction times of each condition (ambiguous vs. non-ambiguous). The mean of the ambiguous condition was 6.24% higher than the mean of the non-ambiguous one. This difference was not statistically significant (528ms. vs. 497ms, $t(13)=1.27$, $p=0.23$), which reveals that there was not local ambiguity effect in the Phonological Phrase Condition. The target word was easier to be identified in this condition than it was in the Prosodic Word Condition. Thus, the presence of a possible competitor word overlapping the phonological phrase boundary did not substantially interfere in the access to the target word as when the competitor was over a prosodic word boundary.



Graphic 2: *Phonological Phrase Condition: Mean reaction time – ambiguous x non-ambiguous*

4. Discussion

We conducted two experiments with BP adult speakers using ambiguous sentences in word detection tasks. We observed a significant local ambiguity effect when the target word was followed by a prosodic word boundary. (Exp.1). On the other hand, this effect was not statistically significant when the target word appeared just before a phonological phrase boundary (Exp.2). Thus, our results suggest that phonological phrase boundaries constrained lexical access by BP speakers, whereas prosodic word boundaries did not.

These results support two main interpretations: first, the competitor word received reduced activation when it overlapped a phonological phrase boundary compared to when it spanned a prosodic word boundary, since the difference between reaction times of ambiguous and non-ambiguous sentences was 142ms in the first experiment and just 31ms in the second one. It seems, therefore, that prosodic information at the boundary between two phonological phrases makes the identification of the sequence [...gol] ϕ [fi...] less plausible to be identified as a single morphological word ("golfe") than [...gol ω fi...]. According to the second interpretation, phonological phrase boundaries may be taken as the end of morphological words. Analyzing the overall reaction times of each condition, there is a difference of 98ms between the experimental sentences of Prosodic Word Condition and of Phonological Phrase Condition. Thus, listeners could relate a phonological phrase boundary to a morphological word boundary and delimitate more easily the end of a word in the speech stream.

Although BP and French seem to present different pitch contour patterns, our results were similar to the French ones, in which prosodic word boundaries could not inhibit the activation of lexical competitors and, on the other hand, phonological phrase boundaries were a relevant cue in the constraint of lexical access.

5. Conclusions

This work reported inedited findings on the processing of BP by native adult speakers, with respect to prosodic restrictions in on-line lexical access. We investigated whether the boundaries of two different types of prosodic constituents would be able to inhibit the activation of ambiguous candidate words. Our experiments yielded two main results: first, BP listeners were sensitive to the pitch differences between the two types of prosodic constituents studied. Second, phonological phrase boundaries were exploited on-line to constrain the lexical access of the target words, whereas prosodic word boundaries failed to block the activation of lexical competitors. Thus, there was a significant interaction between the type of prosodic boundary and the local ambiguity effect. Despite the differences between BP and French pitch contour patterns, phonological phrase boundaries revealed to be a consistent cue to constrain on-line lexical access by speakers of both languages.

6. Acknowledgements

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