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OYEDEJI MUSILIYU

ELECTROPHYSIOLOGICAL CORRELATES OF PROSODIC BOUNDARIES AT DIFFERENT LEVELS IN BRAZILIAN PORTUGUESE.

Maceió
Maio de 2018

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Tese de Doutorado apresentada ao Programa de Pós-graduação em Letras e Linguística da Universidade Federal de Alagoas, como requisito parcial para obtenção de grau de Doutor em Letras e Linguística.

Orientador: Prof. Dr. Miguel Oliveira Jr.

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Apêndice: f. 115-142.
Anexos: f. 143-144.

1. Língua portuguesa – Teoria. 2. Análise prosódica (Linguistica). 3. Closure positive shif. 4. Compreensão da fala. 5. Processamento da fala. I. Título.

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A Deus.

À minha família e aos meus companheiros
que me incentivaram.

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RESUMO

Em tarefas envolvendo a compreensão da fala, sinais prosódicos servem como um guia para processamento linguístico adequado. Em uma oração, por exemplo, existe um conjunto claro de sinais prosódicos (alongamento silábico pré-fronteira, variação do *pitch*, pausa) usados para segmentar e organizar a fala em constituintes prosódicos, a saber, frases entonacionais (IP) e enunciados fonológicos (U). Embora esses dois constituintes prosódicos mais altos sejam delimitados por esse mesmo conjunto de sinais acústicos, suas respectivas fronteiras coincidem com diferentes fronteiras sintáticas. Até a elaboração desta pesquisa, nenhum estudo comparou as respostas neurais a esses sinais nas fronteiras desses dois constituintes prosódicos distintos. Esta tese investigou as diferenças fonéticas entre as fronteiras associadas a esses constituintes e teve como objetivo fornecer evidências da detecção dessas diferenças por meio de um experimento que examinou um componente de ERP, conhecido como *Closure Positive Shift* (CPS), em resposta ao processamento de sinais acústicos, sinalizando fronteiras prosódicas. Os resultados revelaram diferenças na gradação fonética entre as fronteiras de IP e U, assim como refletidas nos parâmetros acústicos. A análise preliminar dos dados do experimento comportamental revelou um componente do ERP eliciado em resposta ao processamento dessas fronteiras. Esses resultados sugerem que, na compreensão da fala, os ouvintes são sensíveis à gradação de sinais prosódicos associados à informação sintática de diferentes níveis.

Palavras-chave: Compreensão da Fala. Processamento da Fala. Sinais Prosódicos. Fronteira Prosódica. Closure Positive Shift (CPS)

ABSTRACT

In tasks involving spoken language comprehension, prosodic cues serve as a guide to adequate linguistic processing. In a statement, for instance, a clear-cut set of prosodic cues (*i.e.*, pre-final syllable lengthening, pitch range, pause) is used to segment and organize speech into prosodic constituents, namely intonational phrases (IP) and phonological utterances (U). Though these two highest prosodic constituents are delimited by this same set of acoustic cues, their respective boundaries coincide with different syntactic boundaries. No study has compared neural responses to these cues at boundaries of these two distinct prosodic constituents so far. The present thesis investigated phonetic differences between boundaries associated with these constituents and aimed to provide evidence of detection of these differences by way of an experiment examining an ERP component known as Closure-Positive-Shifts (CPS) evoked in response to processing of acoustic cues signaling prosodic boundaries. The results revealed phonetic strength differences between IP and U boundaries as reflected in acoustic parameters. The preliminary analysis of the behavioral experiment revealed an ERP component elicited in response to processing of these boundaries. These results suggest that, in speech comprehension, listeners are sensitive to prosodic cues associated with syntactic information of different levels.

Keywords: Speech Comprehension. Speech Processing. Prosodic Cues. Prosodic Boundary. Closure Positive Shift (CPS)

LISTE OF FIGURES

Figure **Description** **Page**

LISTE OF TABLES

Table **Description** **Page**

CONTENTS

1. INTRODUCTION

Written language generally has a clear structure, due to the use of typographic conventions such as punctuation marks, like commas and periods. Speech, however, involves a fleeting series of connected sounds, with no indisputable structuring protocol. There are specific mechanisms that are used to signal the structure of spoken discourse, nonetheless. Several studies have shown that prosody is often used to organize speech into a series of hierarchically arranged, coherent macro units (GELUYKENS & SWERTS, 1994; GROSZ & HIRSCHBERG, 1992; PASSONNEAU & LITMAN, 1993). Attempts to provide phonological evidence to support prosody as a guide in structuring speech led to the development of Prosodic Phonology theory (LIBERMAN & PRINCE, 1977; SELKIRK, 1980, 1984; NESPOR & VOGEL, 1983; BECKMAN & PIERREHUMBERT, 1986; LADD, 1986; LADD & CAMPBELL, 1991), which proposes that the flow of speech is organized into a finite set of phonological units, or "prosodic constituents". These constituents are composed of hierarchically arranged components from lowest to highest, as follows: syllable (σ), foot (Σ), phonological word (ω), clitic group (C), phonological phrase (ϕ), intonational phrase (IP) and phonological utterance (U). According to latter studies, these units of speech, principally at suprasegmental levels, are generally separated by means of prosodic boundaries signaled by set of acoustic cues such as pause, pitch variation and speech rate.

Studies have shown that the use of these acoustic prosodic cues facilitates syntactic structure representation and semantic identification of the speech units, and explains the speaker's intentions towards his/her audience (OLIVEIRA & SILVA, 2011). Specifically, from a language perception perspective, there is an increase in experimental studies focusing on brain processing of speech perception with the advent of non-invasive techniques such as electroencephalography (EEG). Through this method, among others, an Event-Related Potential (ERP) component named CPS (Closure positive shift) was identified. This component reflects prosodic processing and it was first observed at the intonational phrase boundary that indicates the end of such phrase (STEINHAUER et al., 1999; PANNEKAMP et al., 2005).

In that perspective, this study intends to investigate electrophysiological correlates of boundaries of the two uppermost constituents (intonational phrase boundary (*IPB*) and phonological utterance boundary (*UB*)) of the prosodic hierarchy in Brazilian Portuguese (henceforth BP). To this aim, acoustic prosodic cues signaling the boundaries of these two constituents are measured and phonetic strengths between these cues are examined. By way of an ERP experiment, brain electrical signals evoked in response to processing of these acoustic cues marking these prosodic boundaries are extracted and the modulation (in terms of onset latency, amplitude, duration and scalp distribution) of the signals is examined.

Considering the fact that *IPB* and *UB* constitute distinct prosodic constituents in the prosodic hierarchy, we advanced the following hypothesis: (i) there will be differences between the acoustic cues signaling *IPB* and *UB*, (ii) the CPS component of ERPs will be elicited in response to the processing of prosodic boundaries associated with *IPB* and *UB*, and (iii) the CPS will be modulated as a function of phonetic strength differences between the acoustic prosodic cues marking the two boundaries.

2. PROSODY

2.1. Prosody and intonation

The term "prosody" dates back to the Greeks. It was used to describe the features of speech that were not indicated by the spelling, specifically the tone or melodic accent that characterized the words of the ancient Greek (COUPER-KUHLEN, 1986). Prosody can be defined as a phenomenon involving acoustic parameters such as pitch, duration and intensity (LADD & CUTLER, 1983, p. 1). Thus, it covers intonation, stress, phrasing and the precise timing of words in a sentence (BÖGELS et al., 2009, p. 2).

Prosody, as a term, has generally been used as equivalent to "intonation" in the literature. There is a lot divergence between the authors, especially about the difference between the definitions of the two terms. Hirst and Di Cristo (1998, p. 4) state that the term prosody, as suprasegmental, relates to a broad sense unlike intonation that is restricted to what is sometimes called supra-lexical, post-lexical, or simply non-lexical characteristics, as illustrated in Figure 1.

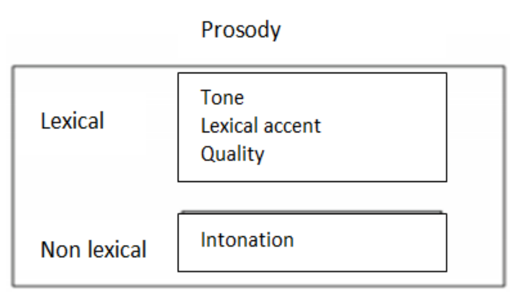


Figure 1: Relation between prosody and intonation
Adapted from: Hirst and Di Cristo, (1998, p. 4)

Couper-Kuhlen (1986, p. 71) also presented that distinction noting that, in the strict sense of the speech melody, the intonation is seen in this model as a manifestation of the interaction of various prosodic features, such as tone and pitch range. Other prosodic features such as loudness, rhythm, pause, etc., can, however, also enter into this case; as such, we will be talking about intonation in its broadest sense, or in other words prosody. In this study, the term intonation will be defined as a part of prosody related to the variation of the fundamental frequency (henceforth, F0) in speech (melodic variation) (KENT & READ, 1992).

As regards the latter mentioned prosodic feature, it is observed that during the speech production process, we expel the air which goes through the phonation system by activating the muscles of the larynx and, in sequence, leading to the vibrations of the vocal folds. These vibrations are described by the F0, the acoustic correlate of intonation (air pressure variation in the larynx when human speech is generated) corresponding to the first harmonic which composes a sound wave. The unit of measurement of the F0 is the Hertz (Hz), which marks the number of complete cycles of each vocal fold vibration per second. The F0 is to the listeners the acoustic correlate responsible for the perception of pitch. Sounds associated with low frequencies are perceived as bass sound and those with higher frequencies are perceived as acute sound. The F0 can range from 60 to 240 Hz in adult men and from 180 to 400 Hz in adult women. For adult men, it revolves around an average of 120 Hz, for adult women, around 225 Hz and in children, around 265 Hz (CRUTTENDEN, 1986). Other relevant prosodic features, such as pause and duration, are considered in the present study. They will be discussed in detail in the next paragraph.

Pauses are mainly considered as "a silent interval in a person's speech" (O'CONNELL & KOWAL, 1983, p. 221). Of course, all "silent intervals" are not pauses, and not just "silent intervals" that characterize a pause. For a "silent interval" to be considered a pause, it has to take place between vocalizations. In other words, the silent gaps that occur in speech caused by reticence or ellipses, for example, are not considered pauses. In addition, other phenomena that do not necessarily meet the definition of pause given above are sometimes considered as pause in the literature, such as filled pauses (vocal hesitations: "uh," "er", etc.), repetitions, false starts, syllabic or vowel lengthening, discourse markers, etc. (O'CONNELL & KOWAL, 1983, p. 221). Among all the prosodic cues available to the speaker to signal the structure of a text, the pause is generally perceived as one of the most efficient (ROSENFIELD, 1987; COLLIER et al., 1993) and it is considered an "interval of silence" greater than 150 milliseconds (ms) (KOWAL, WIESE & CONNELL, 1983).

The language units (utterance, pause, syllable, or segment) can be analyzed based on production duration. Production of language units duration involves coordinating the movements of the articulators (lips, tongue, etc.), with the absence or presence of phonation. The duration measurement unit is typically given in seconds (s) and milliseconds (ms). The average speech rate of a native fluent speaker of Brazilian Portuguese, according to previous studies (OLIVEIRA, 2000; MARTINS & REGINA, 2008), ranges from 3.2 to 5.5 syllables per second (Syll/ s), depending on many factors, such as age, context and content of the utterance. One of the problems regularly pointed out as regards this parameter is to determine exactly at what points in the continuous speech, one must take the measurement (LEHISTE, 1970). Another important issue to take into account is the fact that segments have observed variable intrinsic duration. Thus, for example, the vowel [a] in Portuguese is usually longer than the vowels [i] and [u] (ESCUDERO et al., 2009). The phonetic environment may also affect the duration of vowels. Thus, for example, a vowel followed by a voiced consonant is generally higher than the same vowel followed by voiceless consonant. To minimize the effects of intrinsic duration and duration variability (a segment can last more simply because it is more elastic, variable), it is recommended that a normalization procedure should be applied in studies involving the prosodic parameter of duration. For the normalization, the statistical procedure z-score is used, and the result is in standard deviation units. The z-score value specifies the distance of a measured value from its mean, considering the variance. The z-score is obtained through the formula presented in Figure 2:

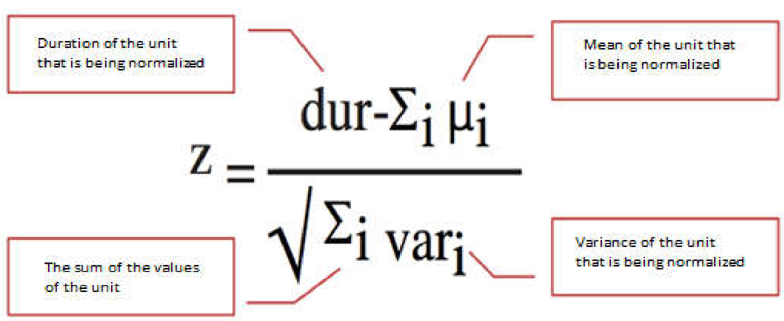


Figure 2: z-score formula

At this point, it is worthy to review the syllable that we earlier defined as one of the language units. According to O'connor and Trim (1953), syllable, in structural terms, is as a combination of phonemes composed of a vowel and followed by a consonant or a combination of consonants permitted by the language. According to Câmara Jr. (1979), the syllable is a functional unit of second degree considering the phonemes.

The syllabic structure is about the organization of vowels (V) and consonants (C) in the formation of syllables of words, and languages have different syllabic structures. Some very interesting analyses regarding syllable in Portuguese are presented by Collischonn (2005). The author states that the syllabic mold determines the maximum and minimum number of elements allowed in a syllable in a given language (COLLISCHONN, 2005, p. 117). There is in the literature a disagreement over what would be the maximum number of elements that a syllable in Portuguese may contain, since this number varies according to the approach of analysis (MARQUES, 2008, p. 65). However, Collischonn (2005) presents some syllabic patterns for Portuguese, illustrated in the following Figure 3:

V	é
VC	ar
VCC	instante
CV	cá
CVC	lar
CVCC	monstro
CCV	tri
CCVC	três
CCVCC	transporte
VV	aula
CVV	lei
CCVV	grau
CCVVC	claustro

Figure 3: syllabic patterns of Portuguese and examples
Source: Bisol (2014, p. 115)

In Portuguese, it is observed that the core of the syllable is always a vowel. The possibilities of syllabic structures above are considered in this study.

Bechara (2003, p. 60) states that vowels and consonants can be distinguished only by the acoustic and physiological conditions of their production. We focus, briefly, on the diphthong which is a fulfillment of those conditions. According to the author, the diphthong is the meeting in the same syllable of a vowel and a semi-vowel, or vice versa. According to Câmara Jr. (1979), the diphthongs have the standard syllabic structure VV. Thus, for example, in "leite" (milk, in English) we have, in terms of phonological representation, the structure set out in Figure 4.

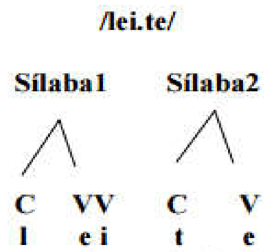


Figure 4: Syllabic representation of "leite"
Source: Toledo and Monaretto (2010, p. 3)

2.2. Prosodic Phonology

This subsection outlines the theoretical basis of the Prosodic Phonology, as proposed by Selkirk (1978, 1980) and developed by Nespor and Vogel (1982, 1986). Furthermore, it focuses, in particular, on phonological constituents which are pertinent in this study.

2.2.1. Syntax-phonology interface

The basics of Prosodic Phonology theory propose a structure of prosodic constituents from a nonlinear phonological theoretical model, that is, a model composed of different hierarchical levels. Selkirk (1984), Nespor and Vogel (1986) established that the model is based on the relationship between phonological structure and other grammatical components, such as syntax, morphology and pragmatics. This relationship is not governed by a form of isomorphism, in other words, there may be coincidence or divergence between these structures. Accordingly, these authors have defended that speech flow is arranged into a finite set of hierarchically organized phonological domains, more or less reflecting syntactic constituency.

In that perspective, we briefly look into theories accounting for syntax-phonology interface. The main concept assumed within these theories is that phonological rules can refer to (limited) syntactic information as domains for their application. Yet, in the literature, the nature of this relation is subject to discussion leading to the development of two main approaches of syntax-phonology interface: direct and indirect reference accounts.

The concepts within the direct reference account theories, mainly developed by Kaisse (1985) and Odden (1990), are as follows: i) The phonological rules can refer directly to syntactic information as domains for their application; ii) The direct reference presents no mediation and thus imposes no mapping rules.

As for the indirect reference account theories, there are two main theories of the interface, which are the following: i) End-based; ii) Relation-based theories. The end-based theory, proposed by Selkirk (1984), assumed that the relation between syntactic structure and prosodic structure above the foot and below the intonational phrase is defined in terms of the ends of syntactic constituents of designated types (Selkirk, 1986, p. 395). That is, the right or left boundary of a prosodic constituent corresponds to the right or left edge of morphosyntactic category X (lexical head or XP). In the relation-based theory proposed by Nespor and Vogel (1986) and Hayes (1989), a phonological phrase consists of a syntactic head and elements on its non-recursive side that are not themselves syntactic heads.

2.2.2. Prosodic constituents

At this point, more light will be shed on the phonological constituents that are relevant for this study. However, before proceeding, we deem necessary to furthermore note that, the theory of phonological domain we are considering, according to Nespor and Vogel (1986, p. 6), is “a theory that organizes a given string of language into a series of hierarchically arranged phonological constituents that in turn form the contexts within which phonological rules apply”. As explained by the authors, there are seven components that make up the prosodic hierarchy, previously presented in the introduction section, from the lowest to the highest as follows: syllable (σ), foot (Σ), phonological word (ω), clitic group (C), phonological phrase (ϕ), intonational phrase (IP) and phonological utterance (U). That hierarchy is illustrated in the tree diagram below, in Figure 5:

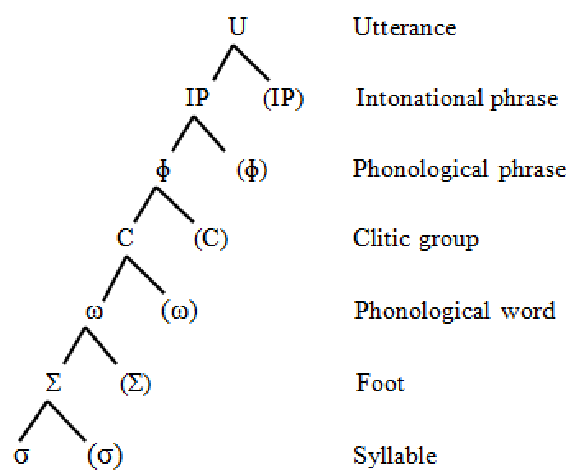


Figure 5: The tree diagram of prosodic hierarchy
Adapted: from Bisol (2014, p. 260)

As Bisol (2014, p. 261) points out, the principles guiding the prosodic hierarchy, mentioned above, are as follows:

i. A given non-terminal unit of the prosodic hierarchy, X^p, is composed of one or more units of the immediately lower category, X^{p-1};
ii. A unit of a given level of the hierarchy is exhaustively contained in the immediately upper unit of which it is a part;
iii. The hierarchy structures of the prosodic phonology are n-ary branching;
iv. The relative prominence relation, defined for sister nodes, is such that one node is assigned the value strong (S) and all the other nodes are assigned the value weak (W).

In view of the principles explained above, the formation of a prosodic constituent, according to Nespor and Vogel (1986, p. 7), abides by the following rule:

- ✓ All X^{p-1}, included in a string delimited by the X^p domain, are incorporated in X^p.
- ✓ In this rule, X^p is a constituent (foot, phonological word, clitic group etc.) and X^{p-1} is the constituent immediately lower in the hierarchy.

So, the production of discourse[1] would involve concatenation of phonological units into syllables, syllables into words, words into phrases (phonological and intonation) and phrases into utterances. This is a theoretical model that has been widely used in the analysis of various languages (FROTA, 2000; SELKIRK, 2000; HELLMUTH, 2004; BALTAZANI, 2006). Some of these studies have an experimental basis. For example, some results have shown, from experimental acoustic analysis, that the constituents proposed by Prosodic Phonology are actually segmented by various prosodic cues, such as the final stressed syllable lengthening (WIGHTMAN et al., 1992), variation of F0 (SERRA & FROTA, 2008), laryngealization and glottalization (TURK, 2010; ERNESTUS, 2000). Importantly, experimental studies often have the power to validate (or not) the proposed theoretical models. In accordance with the objective of the present thesis, we focus only on intonational phrase (IP) and phonological utterance (U) domains in the prosodic hierarchy. In the next subsection, we define in detail these two prosodic constituents.

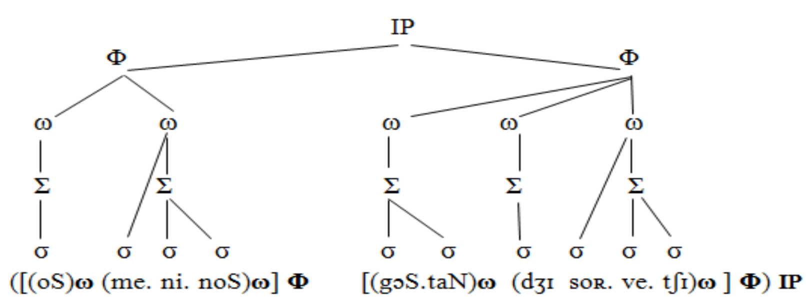
2.2.2.1. Intonation Phrase (IP)

According to Nespor & Vogel (2007) the IP is the prosodic constituent that constitutes the domain for the intonation contour. In other words, it necessarily contains one and only one nuclear contour. In stress languages like English and Portuguese (where some syllables will be longer and some shorter), the nuclear contour is the melody on the nuclear syllable and

[1] The definition of discourse has been a widespread debate in the literature, a point that will not be reviewed in this study. In this study, "discourse" will be considered, as defined in Prosodic Phonology, a structural component above the phonological utterance.

subsequent post-tonic syllable(s) and like in most Romance languages nuclear prominence is rightmost within the IP (NESPOR & VOGEL, 2007; LADD, 2008).

Selkirk (1984, 1986) defends that the level of the IP is determined semantically rather than from syntactic structure. The author, therefore, confines her theory to defining levels of word and phonological phrase. Other researchers, according to Rice (1987), propose that the IP, like the lower levels of prosodic structure, is determined from syntactic structure. Amongst those who suggest that the IP is part of the prosodic hierarchy (SELKIRK, 1978; NESPOR & VOGEL, 1982, 1986; HAYES, 1984), there is a general understanding that certain types of syntactic constituents obligatorily define IPs. These are the edges of parentheticals, non-restrictive relative clauses, and constituents displaced by stylistic or root transformations. Also, as observed by Hayes (1984), the boundaries of clauses and the break between subject and verb phrase tend to attract IP boundaries. However, according to Rice (1987, p. 39), these latter boundaries can be overruled by both phonological factors and semantic factors. The author further explains that phonologically, there is a tendency for IPs within an utterance to be similar in length. Martins (2007, p. 19) defines the IP as a prosodic phrase that groups syllables, metrical feet, phonological words and phonological phrases in a single unit. Observe, for example, the affirmative sentence "*os meninos gostam de sorvete*", ("the boys like ice cream", in English), in Figure 6.



Syntax: ([(Os)Art. (meninos)N.] NP. [(gostam)V (de sorvete) PP.] VP) S.
Fonology: ([(oS)ω (me.ni.noS)ω] ϕ [(gɔS.taN)ω (dʒɪ soʀ.ve.tʃɪ)ω] ϕ) IP

Figure 6: Prosodic hierarchy of the intonational phrase "*os meninos gostam de sorvete*" with an illustration of the syntax-phonology interface at the bottom.
Source: Martins (2007, p. 20).

In her book titled *"Introdução a estudos de fonologia do português brasileiro"*, Bisol (2014, p. 266) defines the IP as a set of ϕs or just a ϕ which has an identifiable intonation. The basic rule guiding the formation of the IP is based on the notion that the IP is the domain of an intonation contour and that the ends of IPs coincide with positions where pauses can be introduced (NESPOR & VOGEL, 1986, p. 188).

2.2.2.2. Utterance (U)

The utterance (U) is the highest domain of prosodic hierarchy delimited by the beginning and end of the syntactic constituent X^n. That is an important initial syntactic information to identify the Us, in addition to other cues of prosodic nature: the relative prominence that, in Brazilian Portuguese, attributes a strong stress *S* to the rightmost node. Thus, the U is defined syntactically by initial and final edges of X^n and prosodically by the relative prominence (BISOL, 2014, p. 270). According to Nespor and Vogel (1986, p. 240), Us are identified by syntactic limits and also by the inherent pause, and their restructuration has to follow the following requisites in (i) and (ii):

(i) Pragmatic conditions:
  a) The two phrases should be pronounced by the same person.
  b) The two phrases should be directed to the same person.

(ii) Phonological conditions:
  a) The two phrases should be relatively short.
  b) There should not be pause between the two phrases.

Bisol (2014, p. 270) presents the example (1) below, where two Us are clearly outlined by the pause and the second U introduced by the adverb "*Agora*" (NOW, in English) with opposing value of "*mas*" (BUT, in English). Both the Us, however short, are pronounced by the same person and directed to same interlocutor. With the conditions applied, the sandhi could occur or not:

(1) Without sandhi
[Sim, passar passa.] U [Agora ocupa a estrada inteira.] U
With sandhi
[Siŋ, pasar pasagɔrokupajstradintejɾa] U

For better insight on acoustic prosodic cues signaling *IPB* and *UB* in BP, the following subsection starts with a brief review of the intonation in the theoretical framework of Intonational Phonology.

2.3. Intonational Phonology

Initially proposed by Pierrehumbert (1980) and followed by Ladd (1996, 2008) and Frota (1998), Intonational Phonology is based on the idea that intonation has its own phonological organization. According to Ladd (2008, p. 1) intonation is perceived as the use of suprasegmental phonetic correlates that carry pragmatic meanings at the "post-lexical" level or, at sentence level, in a linguistically structured way.

One of the fundamental assertions of Autosegmental and Metric theory of Intonational Phonology (LADD, 1996) is that the F0 should be interpreted as a sequence of discrete phonological events (LADD, 1992, p. 322) perceived auditorily through the "pitch". These phonological events are called tonal events for having as basic unit the tone. They are represented by the labels H (High) and L (low) and are of two types, used to describe the variations of F0: the pitch accents and boundary tones (HAYES & LAHIRI, 1991, p. 50).

The pitch accents are associated with the stressed syllable, whose prominence is (somehow) defined independently from intonation contour. Formally, they are indicated by an asterisk (*) and can be simple (high H *, or low: L *) when formed by a tone, or complex when composed of two tones (LH*, L*H, HL*, H*L). The second type of tonal event, boundary tone, is formally indicated by L% or H% (HAYES & LAHIRI, 1991; LADD, 1996, among many others) or Li or Hi (FROTA, 1998, 2002). As the name suggests, these tones are linked to boundaries of prosodic constituents and not only to the syllables themselves as such, in other words, the tonal variation is observed at the constituent´s boundary (HAYES & LAHIRI, 1991, p. 51)

According to Tenani (2002, p. 30), the distinction between pitch accents and boundary tones is related to the conception of the prosodic structure, and the tonal accents are set based on the relationship of prominence within the prosodic domains and boundary tones, based precisely on the boundaries that delimit these domains.

As regards the intonational phrase, Tenani (2002) notes that: (i) When there is a pause between IPs (Is, according to TENANI, 2002), as in the example of Figure 6, it easier to identify the intonational features of the IP. In addition to the pause, according Tenani (2002), there is a boundary tone, which preferably takes place as Hi, which precisely defines the IP´s boundary. The last stressed syllable of IP which does not coincide with the end of U is associated with a tonal event LH*, as in the example of Figure 7, which characterizes “continuative tone” or “suspension tone”, or with a tonal event HL*, as in the example of Figure 8, which characterizes the end of a declarative statement.

[[A Alice vai pra Souzas,] *I* [apesar de haver riscos.] *I*]*U*

alisɪ vai pɾa souzas / apezaɾ dʒɪaveɾ xiskus
LH* L* LH* Hi L* HL* Li

Figure 7: Prosodic hierarchy and intonational annotation of the utterance "*A Alice vai pra Souzas, apesar de haver riscos*".
Source: Tenani (2002, p. 78)

[[A Marina não acredita,] *I* [mas eu vi um disco voador.] *I*]*U*

a maɾina nɐ̃ʊ akɾedʒita mazeʊ viũ diskʊ vʊadoɾ
LH* H L* Li L* L* HL*

Figure 8: Prosodic hierarchy and intonational annotation of the utterance "*A Maria não acredita, mas eu vi um disco voador*".
Source: Tenani (2002, p. 78)

ii) When there is no pause between IPs, we can observe two intonational strategies that delimit the intonational phrases, namely:

- A change in texture, as illustrated in Figure 9. This strategy prevails when the relationship between the two sentences that form the two IPs is not expressed by a lexical item.

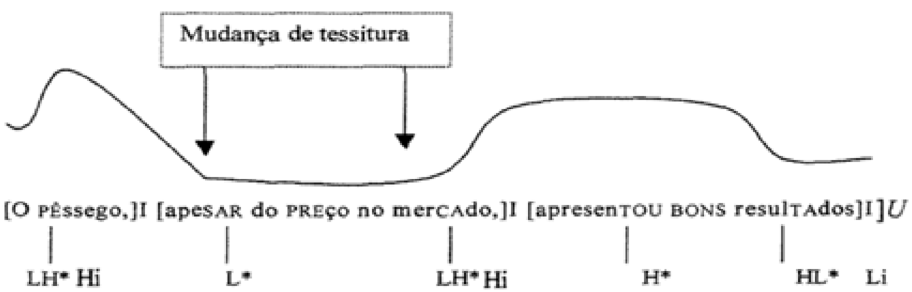


Figure 9: Prosodic hierarchy and intonational annotation of the utterance "*O pêssego, apesar do preço no mercado, apresentou bons resultados*".
Source: Tenani (2002, p. 100).

- A sudden and deep falling or rising of F0 in relation to the baseline of the pitch used by the speaker as shown in Figure 10. The sudden change of pitch is found at the boundary of the IP which does not coincide with the end of the utterance. This strategy prevails when a semantic or syntactic relationship is lexically ensured between the sentences that make the two intonational phrases.

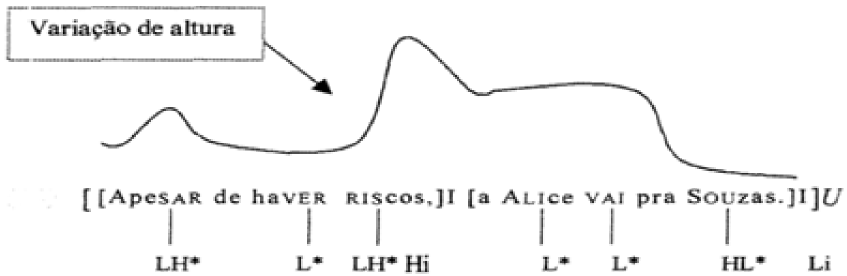


Figure 10: Prosodic hierarchy and intonational annotation of the utterance "*Apesar de haver riscos, a Alice vai pra Souzas*"
Source: Tenani (2002, p. 100)

As regard to the U, the author proposes that it should be characterized as the domain in which the relationship between IPs occurs. The pitch variations identified as typical to the IP´s domain, is observed when the IPs belong to the same U. The analysis of utterances which constitute declarative statement shows that the edge of U is characterized by the occurrence of an HL* tone associated with final stressed syllable of U, followed by a boundary tone Li (TENANI, 2002, p. 291), as in the example Figure 10.

Frota and Moraes (2012, p. 151) described the nuclear contour that characterizes IP and U in declarative statement with basic intonational inventory of pitch accents and boundary tones. According to the authors, in Portuguese, broad focus or declarative statements are characterized by a final fall through the stressed syllable of the nuclear word, which is represented by an accentual low target immediately preceded by a peak (H+L*). The accentual fall is followed by low pitch at the bottom of the speaker's range, or in other words by a low boundary tone (L%). The tonal event H+L*L% is thus the nuclear contour of declarative intonation in Portuguese, as illustrated in Figure 11.

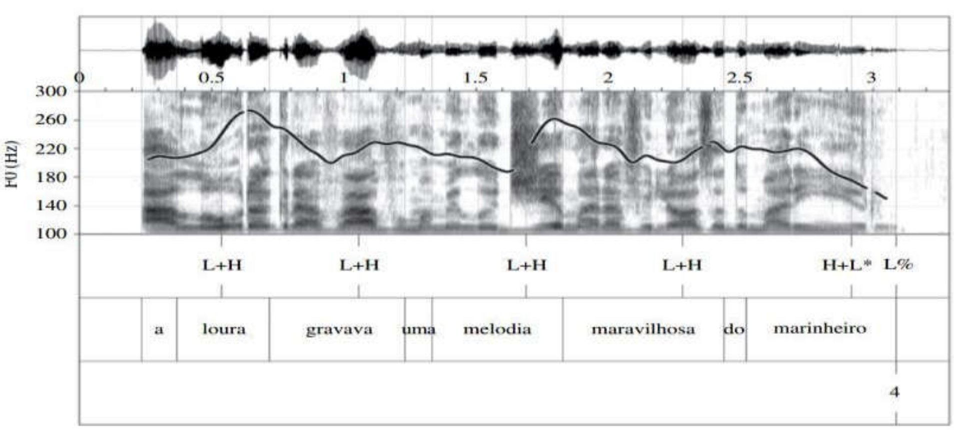


Figure 11: F0 contour of the utterance *A loura gravava uma melodia maravilhosa do lagareiro/ marinheiro* ('The blond girl recorded a wonderful song from the olive-pressman/sailor'), produced by a BP speaker.
Source: Frota and Moraes (2012, p. 143)

As it can be seen in Figure 10, in BP, the prenuclear contour shows a pitch accent per prosodic word. Non-final stressed syllables typically exhibit a rising melody, that has been described either as an L*+H or an L+H* accent (TENANI, 2002; FERNANDES, 2007a, 2007b; MORAES, 2008). Another feature observed in BP is the presence of accentual-like tonal events in pre-tonic syllables. These tonal events, according to Frota and Moraes (2012, p. 153), are usually in the form of high or rising pitch and their distribution may be governed by the number of syllables to the left of the stressed syllable and the presence of secondary stress, but further research is required.

In general, and particularly in BP, as Frota and Moraes (2012, p. 142) stated, the IP boundaries are signaled by final lengthening observed in the pre-boundary stressed vowel, a continuation rise contour (a rising accent LH followed by a high boundary tone, associated with last prosodic word of the IP) if utterance-internal, still a low boundary tone can also be found (FROTA, 2000; TENANI, 2002) and although not required, the pause.

Furthermore, Frota (2000) observed that the rightmost edge of the IP which does not coincide with the end of the utterance is different from the edge of the external IP, simply due to the degree of final lengthening and the magnitude of the pitch range. Thus, the difference in terms of realization, between the inner and outer edge of the compound IP is a gradient type, expressed by the phonetic strength of the same type of cues, and not a different kind of clues that signals the two intonational phrases (IPs) (BARROS, 2014; FROTA, 2000, 2002, 2014).

As regards the stressed pre-boundary vowel, Moraes (1998, p. 180) asserts that in BP, acoustic correlates of lexical stress vary as a function of a word's position in an utterance and, less significantly, as a function of the word's stress pattern. When a sequence of syllables is in a strong position (*i.e.*, at the end of a prosodic group), that is a pre-boundary position, where phrase or sentence level accent is superimposed on lexical stress, fundamental frequency joins duration and intensity[2] as a stress cue. See Figure 12.

[2] Intensity, as a prosodic cue, is not reviewed in this study.

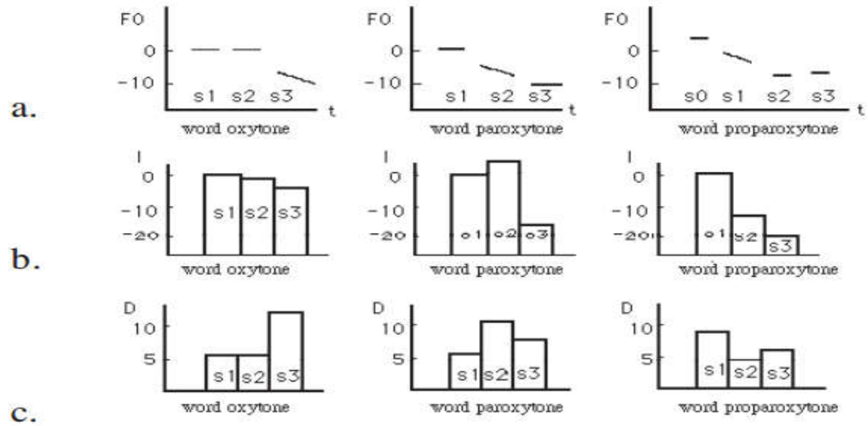


Figure 12: Acoustic correlates of lexical stress at end of a statement: (a) F0 in quarter tones; (b) intensity [I] in decibels; and (c) duration [D] of vowels in centiseconds. Values were obtained using sentences that contained a nonsense word *pipipi* in the location where manifestation of stress was investigated. sl, s2, and s3 represent first, second, and third syllables of word. In the proparoxytone pattern, s0 represents the last syllable of the word that immediately precedes sl.
Source: Moraes (1998, p. 181)

Despite the broadly reviewed definitions in this section, there is, to some extent, a controversy with respect to the existence of a systematic difference between IP and U (KEATING et al., 2004, p. 6). Nespor and Vogel (1986) marked them as distinct on the basis of where some phonological rules apply. Importantly, U consists of at least one IP and can extend the length of the string dominated by the highest node X^n in the syntactic tree. As compared to IP, U is characterized by the intonational contour of a linguistic form which always has pauses both at the beginning and at the end, as well as a complete meaning (ZHANG, 2017). On the other hand, a relatively categorical set of acoustic cues to prosodic constituents across different languages has been reported at the boundary of an IP, namely lengthening of pre-boundary segments (*i.e.*, BECKMAN & EDWARDS, 1990; BECKMAN et al., 1992; WIGHTMAN et al., 1992; CAMBIER-LANGEVELD, 2000; TURK & SHATTUCK-HUFNAGEL, 2000, 2007; BYRD et al., 2006), pitch variation and pause (*i.e.*, NESPOR & VOGEL, 1986; VENDITTI et al., 1996; HIRST & DI CRISTO, 1998; FÉRY et al., 2011).

Studies on Brazilian Portuguese propose that the two highest constituents of the prosodic hierarchy – the IP and U – have their boundaries marked mainly by three major prosodic cues: final lengthening, *i.e.*, an increase in the duration of the stressed vowel of the words immediately preceding the boundaries (MORAES, 1995; SERRA, 2009; SERRA & FROTA, 2009), pitch variation, *i.e.*, boundary tones characterized by a pitch rise or possibly pitch fall for intonational phrase and mainly a pitch fall for utterance (FROTA & VIGÁRIO, 2000; TENANI, 2002; FERNANDES, 2007; SERRA, 2009) and, although not required, a pause (CHACON & FRAGA, 2014). These studies reported that IP and U boundaries are defined by a nuclear contour combining a pitch accent (H+L* or L+H*) and boundary tone (L% or H%) realized on the IP´s final syllable, followed by a potential pause. In stress languages like English and Portuguese, the nuclear contour is the melody on the nuclear syllable and subsequent post-tonic syllable(s) and like in most Romance languages, nuclear prominence is rightmost within the IP (NESPOR & VOGEL, 2007; LADD, 2008). The last stressed syllable of the IP, which does not coincide with the end of the U, is marked by a tonal event L+H* (which characterizes "continuative tone" or "suspension tone", followed by a high boundary tone H%), or tonal event H+L* (characterizing the end of a "declarative statement"). U, constituting a declarative statement, presents a prosodic boundary characterized by a tonal accent H+L* associated with its final stressed syllable followed by a boundary tone L% (TENANI, 2002).

Santana and Leal (2011) discussed syllable duration with respect to different prosodic constituents, namely clitic group (C), phonological phrase (ϕ) and IP. The investigators conducted a production analysis of trisyllabic words and pseudowords with a paroxitone stress pattern, placed at boundaries of each of the constituents. With both the words and pseudowords, results showed that stressed syllables, followed by post-stressed syllables, are longer in terms of duration at the IP boundary as compared to other prosodic boundaries. Using spontaneous speech (SS) and a read speech (RS) version in a perception test, Serra (2016) investigated the correlation between perception and production of spontaneous and read speech breaks and prosodic constituent boundaries, and described the phonological characteristics of perceived and non-perceived breaks. The results revealed that 64% of expected IP boundaries were perceived as breaks in RS as compared to SS, where just 37% were perceived. Though nuclear contour L+H* H% and L*+H H% were reported (34%) at perceived breaks in SS, contour H+L* L% was most observed in both types of speech (RS 67% and SS 30%). This is evidence that RS and SS share the same type of phonological cues which are more consistent in RS, but varied in SS, making systematic perception of IP boundaries in RS easier as compared to SS. This might be due to punctuation in RS. In the following subsections, we review the intonational annotation system ToBI and P-ToBI.

2.3.1. Intonational annotation: ToBI system and P-ToBI (ToBI for Portuguese)

The development of the ToBI system came up due to emergent needs of a research program for intonational phonology, especially the Autosegmental and Metric theory in the 1970s, and the studies of Pierrehumbert in the 1980s (LUCENTE, 2008, p. 7). ToBI - Tones and Break Indices - (SILVERMAN et al., 1992; PITRELLI et al., 1994), is a model of intonational annotation, developed by a group of researchers for American English, with the initial aim of producing a transcription tool that could assist in the understanding and development of speech synthesis and recognition systems that require large amounts of utterances that are prosodically transcribed (SILVERMAN et al., 1992).

In the ToBI transcription system, different tiers are used for annotation, jointly with programs that reproduce and present the F0 curve of speech, *i.e.*, Praat software (BOERSMA & WEENINK, 2018). The different tiers are used to annotate the tone, orthographic transcription, prosodic grouping and any other observation considered important for a given study. They are conventionally named: tone tier, Orthographic tier, break indices tier and miscellaneous tier (see Figure 13, for an example).

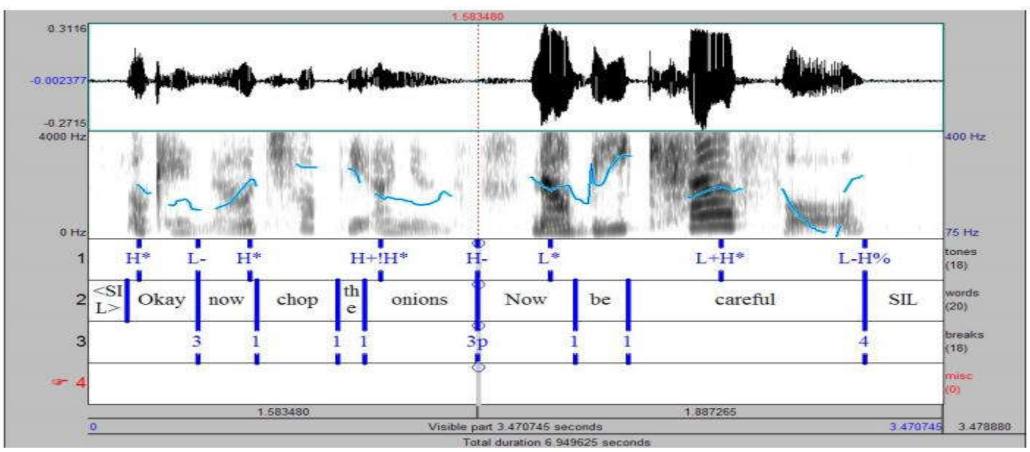


Figure 13: General aspect of annotation proposed by ToBI system with tiers.
Source: Lucente (2008, p. 9)

The ToBI system is a system for the transcription of the intonational and prosodic grammar of a given language. It is important to note that the transcription of intonation in a given language reflects “the understanding of the intonational and prosodic grammar of the language” (BECKMAN et al., 2005, p. 12). In other words, a transcription is an analysis of the intonation system of the language under study (FROTA, 2012-2015). One of the primary goals of such an analysis “should be to discover what the significant categories are for the variety or language in question" (JUN & FLETCHER, 2014, p. 506).

P-ToBI is thus a system for the transcription of the intonational and prosodic grammar of Portuguese. The system was developed within the autosegmental-metrical model of intonational phonology. Since it used a large empirical database comprising several European and Brazilian varieties (and a few data on African varieties), it covers language-specific and variety-specific patterns that are part of the phonology of the language/variety. According to Frota (2012-2015), the present P-ToBI represents the current state of knowledge of the intonational and prosodic grammar of Portuguese. As in most, if not all, scientific fields, such knowledge awaits revision and will evolve with future contributions as more varieties are being analyzed and as the intonational structure of the language is further understood under the challenges of new data.

A P-ToBI record of utterance is based on the ToBI system of annotation, including three main tiers time-aligned with the sound wave, the spectrogram and the F0 contour. The three main tiers are the obligatory symbol strings: The Tone tier, the Orthographic tier and the Break Indices tier, as illustrated above in Figure 13. In P-ToBI, any IP break, whether Compound IP phrasing obtains or not, is signaled by level 4.

Since it appears that the role of prosody as a device in structuring spoken discourse is well described with respect to production, the present study rather aims to investigate its impact in perception, especially when it comes to perception from a neurocognitive perspective. Thus, the (basic) brain network for speech perception is the focus of the following section.

3. BRAIN AND LANGUAGE

3.1. The (basic) brain network for speech perception.

Since the first discovery that language functions are directly related to brain tissue (BROCA, 1861; WERNICKE, 1874; LICHTHEIM, 1884), there has been an increasing interest in understanding the neural basis of language. It is worth recalling that from an observed lesion in the left hemisphere of one of his deceased patients who could only utter a single syllable “tan”, usually twice with expressive gestures in the last twenty-one years of life, Broca (1861) identified an area in the frontal lobe (the area that became known as Broca´s area) which he found to be related to the development of motor acts of speech. For the physiologist Paul Broca, there was an indication that that area, the third inferior frontal gyrus of the cerebral cortex could be a concentration of special nerve cells for movements ordering abilities necessary for speech.

A couple of years later, a neuroanatomist named Wernicke (1874) found that patients with lesions in the cortical area located on the first ascending temporal gyrus in the left hemisphere next to the primary auditory cortex (the area that became known as Wernicke's area) had difficulty with speech and understanding of sentences. According to the neuroanatomist, this area of the temporal gyrus is responsible for processing speech sounds. Unlike the patient observed by Broca, Wernicke´s patients had fluent speech, but with little or no sense. This disorder of language formulation and understanding is called aphasia. A decade later, Lichtheim (1884) added to the research on aphasia. In addition to the symptoms provided by Wernicke, Lichtheim noted that patients with these lesions showed also, as the case would predict, a great difficulty in repeating words or spoken phrases.

From the early lesion studies which discovered that language functions are directly related to brain tissue (BROCA, 1861; WERNICKE, 1874; LICHTHEIM, 1884), in the last century, there has been considerable increase in brain-based language studies with the advent of new techniques such as magnet resonance imaging (MRI), which can be used in vivo to image cognitive functions in the brain (functional MRI or fMRI) as well as gray matter anatomy and white matter fiber tracts (diffusion-weighted MRI), and notably magnetoencephalography (MEG) and electroencephalography (henceforth EEG) that measure, in real time and in a non-invasive manner, the propagation of nervous stimuli in the brain (ARAÚJO et al., 2004, p. 1) during production or perception of speech.

In the recent past, various models describing the neural basis of language and speech have been proposed. Some models primarily focus on the neuroanatomy of speech perception (HICKOK & POEPPEL, 2007; RAUSCHECKER & SCOTT, 2009), whereas others try to specify the functional neuroanatomy of semantic and syntactic processes as well as their time course (BORNKESSEL & SCHLESEWSKY, 2006; FRIEDERICI, 2002). Yet others have considered different memory systems (ULLMAN, 2001) or memory and control systems (HAGOORT, 2005) as major parts of language processing. Taken together, however, these models seem to cover the different components of a language processing system quite well (FRIEDERICI, 2011, p. 1357) and could be implemented considering an EEG-based technique. We therefore deem proper to shed more light on the basics of EEG in the next subsections.

3.1.1. Recording standard of EEG

Electroencephalography (EEG) was discovered in 1929 by Hans Berger (1873-1941), a German psychiatrist. “It is a domain concerning the recording and interpretation of the electroencephalogram. The electroencephalogram is a tool that records electric signal generated by the cooperative action of brain cells, or more precisely, the time course of extracellular field potentials generated by the synchronous action of neuron firing. EEG can be measured by means of electrodes placed on the scalp or directly on the cortex (see Figure 14). In the latter case, it is often called electrocorticogram (ECoG). Electric fields measured intracortically are named Local Field Potentials (LFP). EEG generated as a response to external or internal stimulus is called an event-related potential (ERP) and in the absence of an external stimulus is called spontaneous EEG. The amplitude of EEG of a normal subject in the awake state recorded with the scalp electrodes is 10–100 µV (microvolts)” (BLINOWSKA & DURKA, 2006).

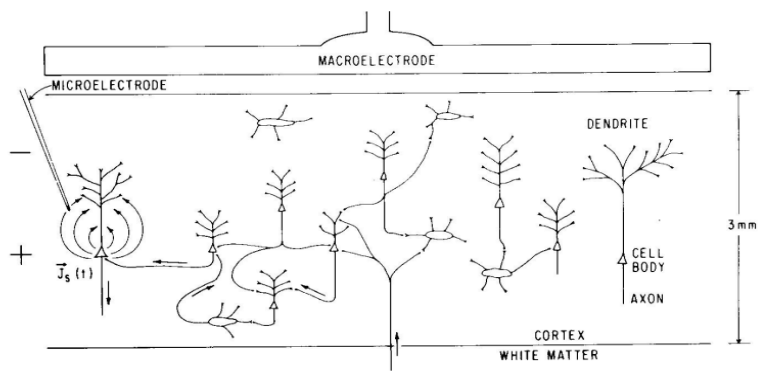


Figure 14: Scalp EEG recording.
Source: Available at: <https://web.cs.dal.ca/~tt/CSCI690611/eeg_intro_lecture.pdf>. Accessed on 10/06/2017.

The electrodes placed on the scalp are usually secured by an adhesive (like collodion) or embedded in a special snug cap. Application of the exact positions of electrodes is very important for both interpretation of a single recording as well as comparison of results, hence there is a standard setting known as the traditional 10–20 Electrode system (see Figure 15). The system establishes the positions of 19 EEG electrodes (and two electrodes placed on earlobes A1/A2) related to specific anatomic landmarks, such that 10–20% of the distance between them is used as the electrode interval as illustrated in Figure 15. In its topographic representation, the 10-20 system has the following derivations: Fp1 and Fp2, pre-fontal electrodes; Fz, F3, F4, F7 and F8, Frontal; T3, T4, T5 and T6, temporal; Cz, C3 and C4, central; Pz, P3 and P4, parietal; O1and O2, occipital; and the A1 and A2, earlobes.

With progress in topographic representation of EEG recordings, there is a demand for a larger amount of derivations. EEG is a measure of potential difference; in the referential (or unipolar) setup, it is measured relative to the same electrode for all derivations. This reference electrode is usually placed on the earlobe, nose, mastoid, chin, neck, or scalp center. No universal consent exists regarding the best position of the reference electrode, because currents coming from bioelectric activity of muscles, heart, or brain propagate all over the human body (BLINOWSKA & DURKA, 2006, p. 4)

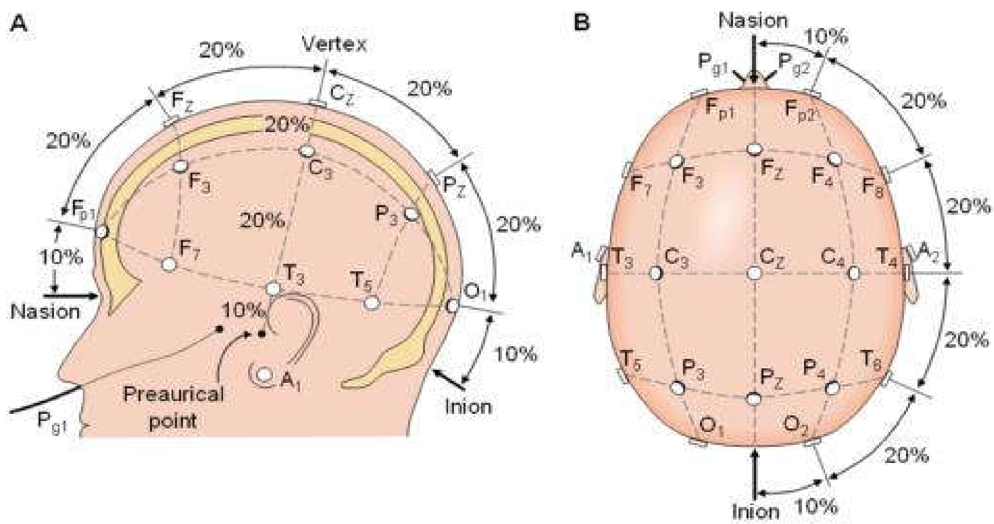


Figure 15: International 10-20 system
Source: Lage (2006, p. 85)

3.1.2. Neurophysiological Basics of EEG.

The electric brain signal, recorded by the EEG on the scalp, primarily derived from postsynaptic activity around the dendrites of the pyramidal neuron in the cerebral cortex. How does the postsynaptic activity, captured by the EEG, get to the dendrites of the pyramidal neuron? Neurons communicate by passing an electrical signal though the movement of irons from in and out of the cell. The basic types and key features of neuron are presented in Figure 16 and Figure 17.

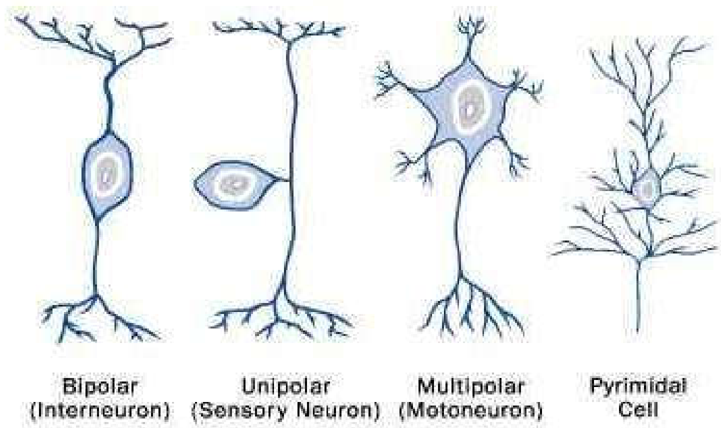


Figure 16: Basic neuron types.
Source: Available at: <https://medicalxpress.com/news/2013-08-neurons.html>. Accessed on 09/06/2017.

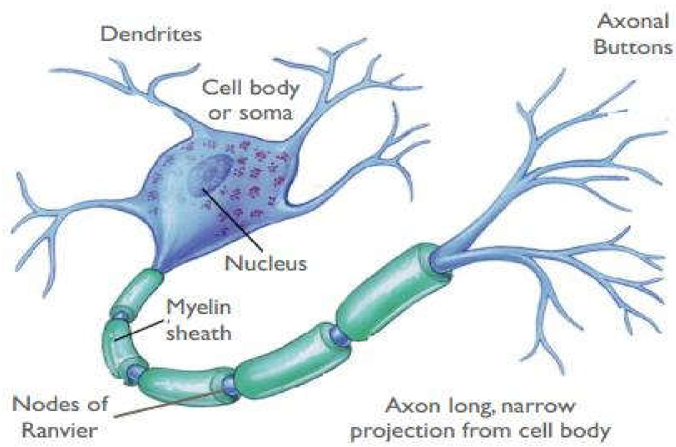


Figure 17: Key features of neuron.
Source: EGI *(Electrical Geodesics, Inc)* summer school 2016. Eugene, Oregon, USA

At rest, the neuron presents an even distribution of iron across its membrane (see step 1 in Figure 18). The inside of the cell is more negatively charge with a higher concentration of sodium iron (henceforth Na+), while the outside is more positively charge with a high concentration of potassium iron (henceforth, K+). That resting phase is called the resting action potential and cell membrane voltage is -70 mV (millivolts) (see Figure 19). When a stimulus or a triggering event (physical, visual, auditory, etc), transmitted by the “sending” neuronal population, gets to the dendrites of the “receiving” neurons, there are graded potentials (an Excitatory Post-Synaptic Potential (henceforth, EPSP) and an Inhibitory Post-Synaptic Potential (henceforth, IPSP)) that activate an inflow of Na+ and an outflow of K+ from in and out of the soma, through iron gated channels (see Figure 20).

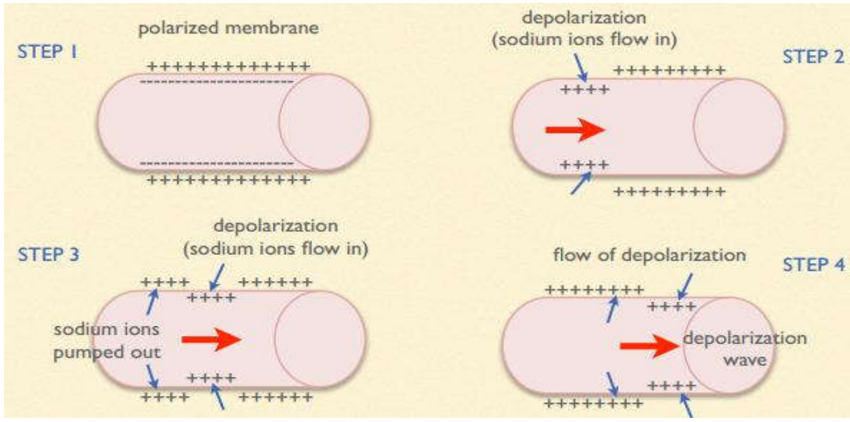


Figure 18: Axional transmission
Source: EGI summer school 2016. Eugene, Oregon, USA

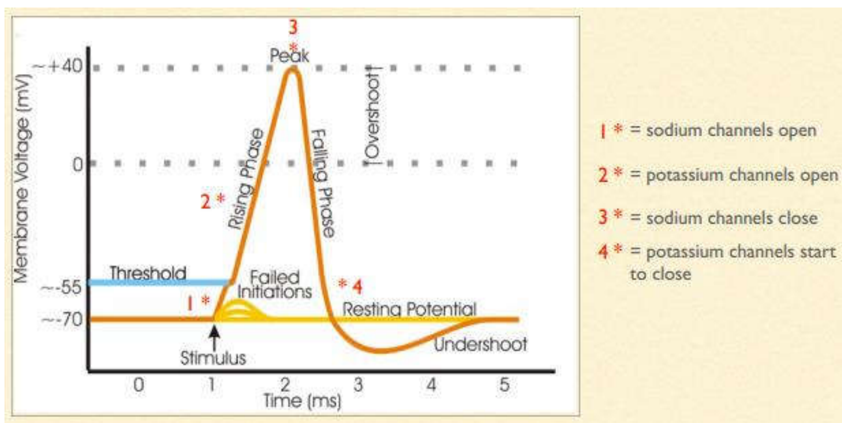


Figure 19: Action potential
Source: EGI summer school 2016. Eugene, Oregon, USA

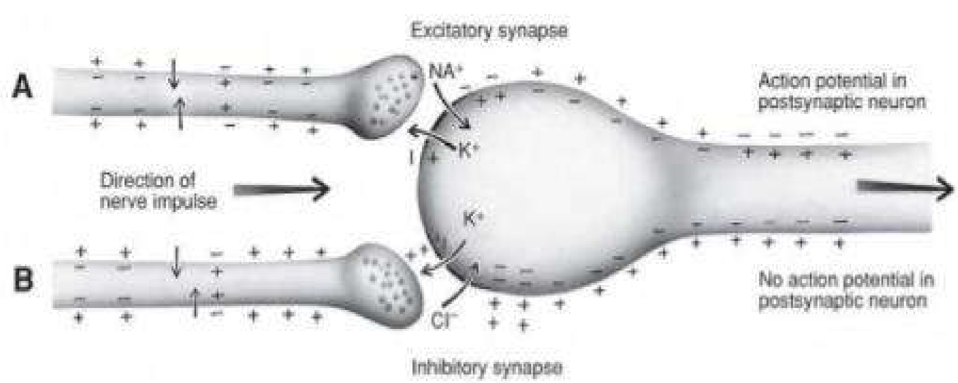


Figure 20: Sequences in excitatory (A) and inhibitory (B) transmission from presynaptic neurons (left) across synapses to postsynaptic neuron (right)
Source: Available at: <http://aibolita.com/nervous-diseases/47834-action-potentials.html>. Accessed on 09/06/2017.

There is actually a greater inflow of Na+ than outflow of K+. If the summation of the ions (Na+ and K+) in the soma, reaches the threshold, the potential of cell membrane varies from -70 mV to -50 mV (see Figure 19). The voltage variation opens the Hillock (gate of the Axon) and the signal gets on to the Axon terminal. The voltage gated Na+ channels of the Axon are first activated and the Na+ rushes into to cell. The inside of the cell becomes more positively charged and the outside more negative. This phase is called depolarization (see Figure 19). When the depolarization gets to its peak (see Figure 19), voltage gated Na+ channels close and the voltage gated K+ channels open temporarily, creating an outflow of K+ from out of the Axon. The inside of the cell becomes more negatively charged again, and the outside more positive. That phase is called repolarization (see Figure 19). Since the voltage gated K+ channels are slow to open and slow to close, the repolarization phase overshoots its normal resting membrane potential (-70 mV) and that creates a hyperpolarization (see Figure 19). The resting membrane potential is subsequently restored (-70 mV) (see Figure 19). At this phase, the depolarization is transmitted down the Axon (Figure 20). The process is complete, and the stimulus signal reaches the synapse of the neurons. This occurrence is called an action potential.

When the action potential of the “sending” neurons gets to the Axon terminals, there is an electrical transmission between its synapses and the dendrites of the “receiving” neurons (in this case, the pyramidal neurons) (see Figure 21). In other words, Axons from neighboring neurons synapse with the pyramidal neurons. It is important to note that pyramidal neurons are found in the most superficial layers of the brain and they are spatially aligned, as illustrated in Figure 22. Thus, their activity is synchronous which produces a larger signal that can be measured superficially from the scalp.

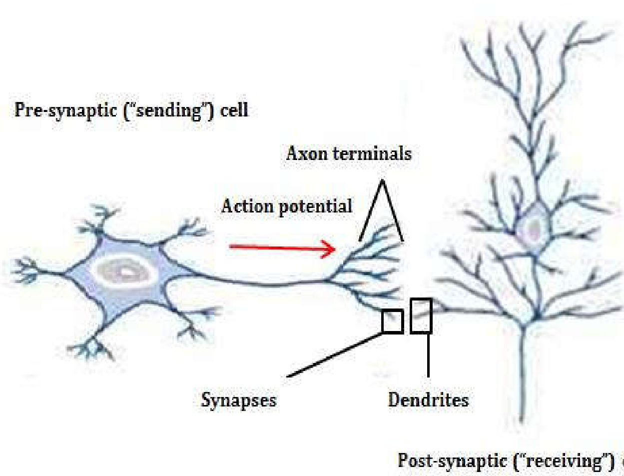


Figure 21: Electrical transmission between nervous cells

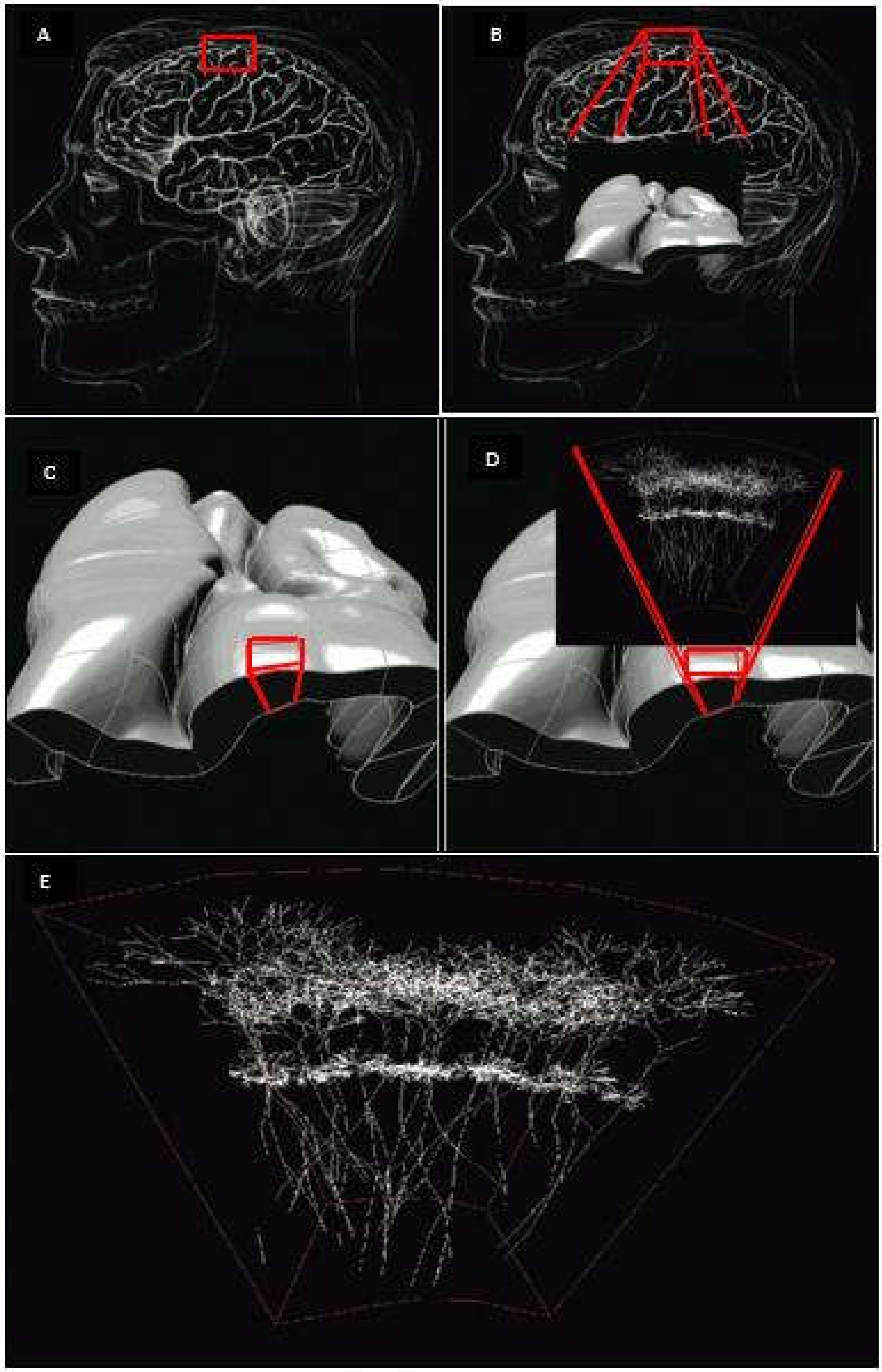


Figure 22: Pyramidal neurons at the most superficial layers of the brain.
Source: EGI summer school 2016, Eugene, Oregon, USA

Inside the Axon terminal of a sending cell there are many **synaptic vesicles** (see Figure 23A). These are membrane-bound spheres filled with neurotransmitter molecules. There is a small gap between the axon terminal of the pre-synaptic neuron and the membrane of the post-synaptic cell, and this gap is called the **synaptic cleft**. The action potential activates voltage gated calcium (henceforth Ca^{2+}) in the cell membrane. Ca^{2+}, which is present at a much higher concentration outside the neuron than inside, rushes into the cell. The Ca^{2+} allows synaptic vesicles to fuse with the axon terminal membrane, releasing neurotransmitter into the synaptic cleft. The molecules of neurotransmitter diffuse across the synaptic cleft and bind to receptor proteins on the postsynaptic cell. Activation of post-synaptic receptors leads to the opening or closing of ion channels in the cell membrane (see Figure 23B). This may be **depolarizing** - making the inside of the cell more positive - or **hyperpolarizing** - making the inside of the cell more negative - depending on the ions involved. These reactions can produce a localized change in the membrane potential - voltage across the membrane - of the receiving cell:

- In some cases, the change makes the target cell *more* likely to fire its own action potential. In this case, the shift in membrane potential is called an **excitatory postsynaptic potential**, or **EPSP**.
- In other cases, the change makes the target cell *less* likely to fire an action potential and is called an **inhibitory post-synaptic potential**, or **IPSP**.

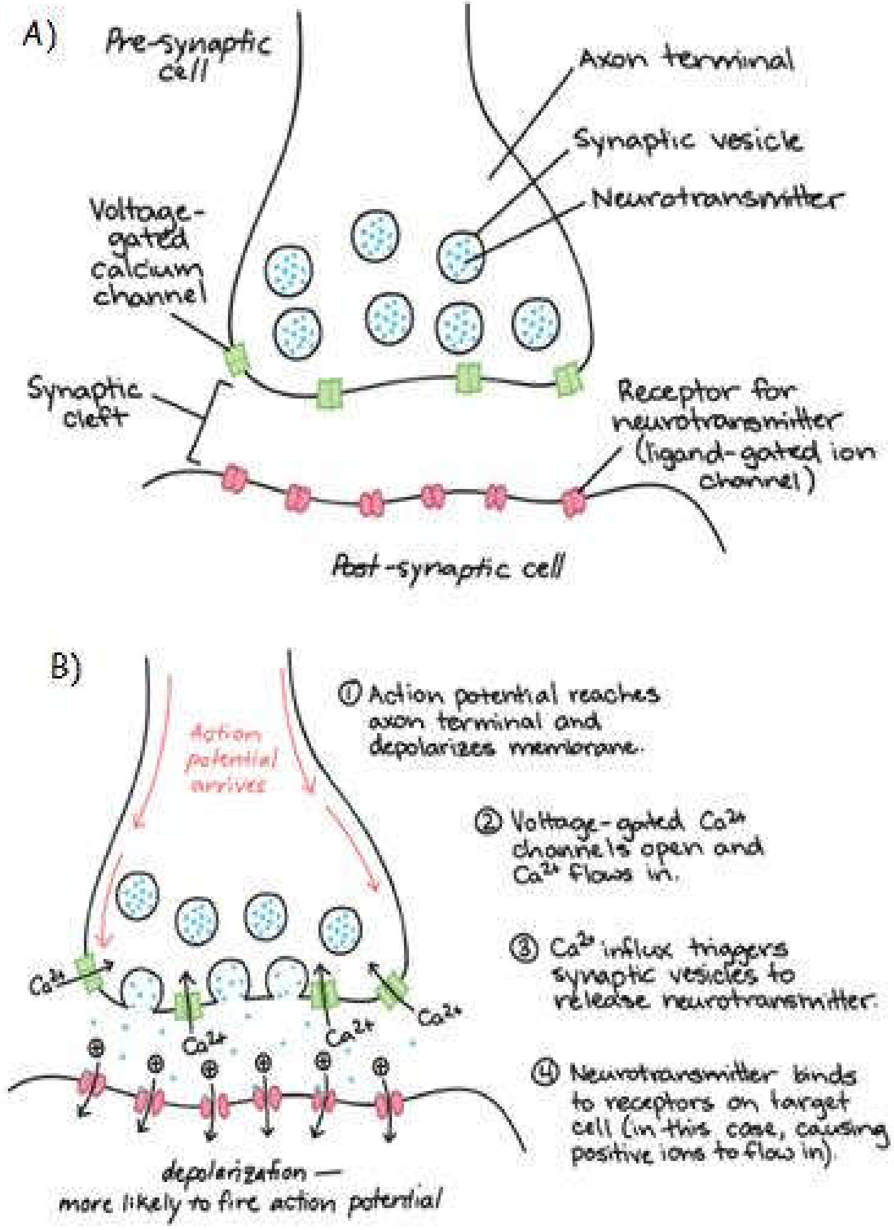


Figure 23: Mechanism of neurotransmitter activation.
Source: Available at: <https://www.khanacademy.org/science/biology/human-biology/neuron-nervous-system/a/the-synapse>. Accessed on 20/07/2017.

When the depolarization of the receiving pyramidal neuron begins at one end, the other end is repolarized back to -70 mV, thus creating dipoles of the neuron and conducting a current (see Figure 24). Every post synaptic potential causes the charge inside the neuron to change and the charge outside the neuron to change in opposition. However, a single electrical event is not big enough to be detected. The summation of the dipoles created by the postsynaptic activities of hundreds to thousands of neurons is what is detected by the EEG (see Figure 24). It is important to remember that regardless of whether an action potential is reached or not, all postsynaptic potentials (including EPSPs and IPSPs) will contribute to the EEG signal.

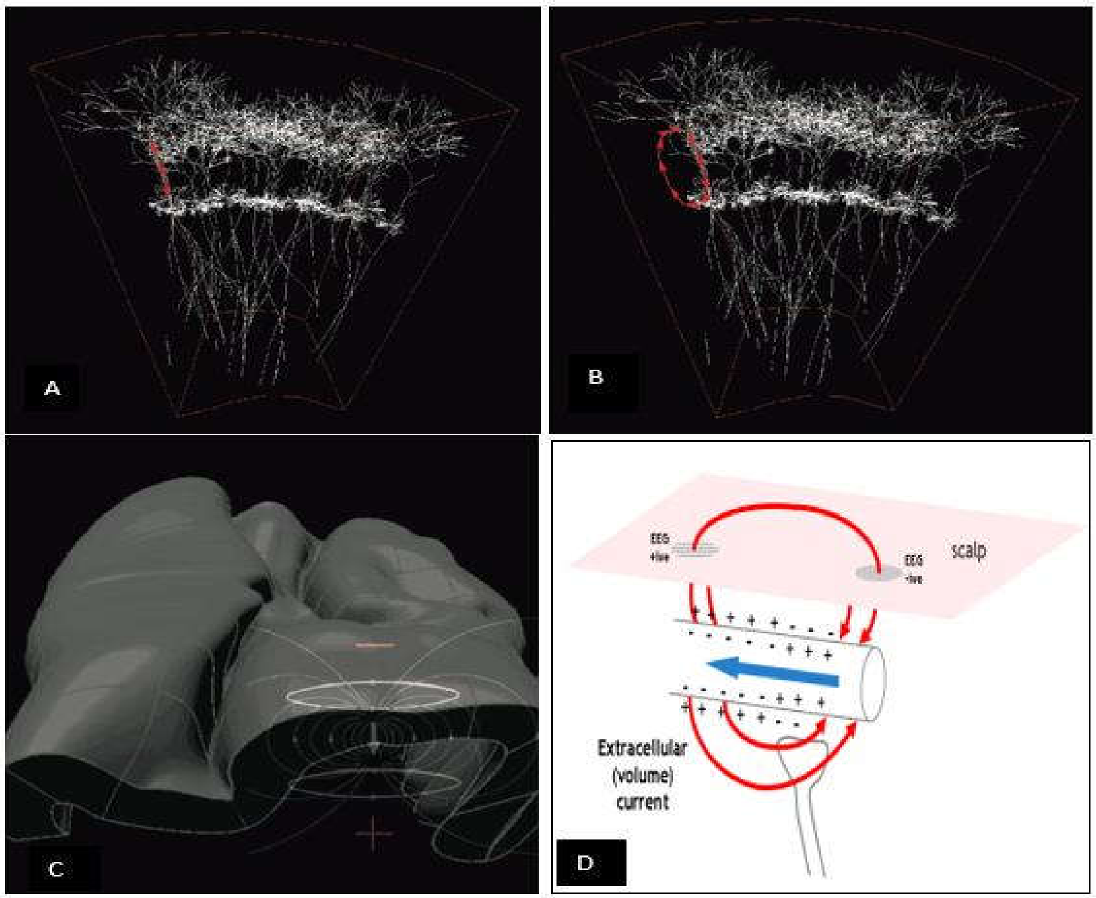


Figure 24: Dipole (electrical field) of pyramidal neuron
Source: EGI summer school 2016, Eugene, Oregon, USA.

As observed, an EPSP constitutes indeed a depolarizing postsynaptic potential. It occurs at cell body region (including **dendrites** and **soma**) designed to respond to triggering events. The intensity and duration of the EPSP, reflecting for example the difference between the new potential and the resting potential, is proportional to the intensity and duration of the triggering event. This shows that the stronger the stimulus, the more Na+ gated channels that are activated, resulting in a greater positive charge within the cell body, and a larger EPSP. For instance, if a postsynaptic membrane depolarizes from -70 mV to -40 mV, the magnitude of the EPSP will be 30 mV, and from -70 mV to -20 mV, it will be 50 mV.

As previously stated, each time threshold is reached in the cell body, contrary to postsynaptic potential (EPSP, specifically), action potential is fired with the same level of intensity by the **axon hillock**. Once triggered by depolarization (mostly through summation of

EPSPs), action potential (which does not summate due to its refractory period) spreads automatically along the **axon** without distortion, in contrast to EPSP that dies out over a short distance. It appears that, for a given **axon**, the duration and amplitude of action potential is constant and independent of the strength of the triggering event. In sum, a stimulus with greater intensity does not trigger longer duration and larger amplitude action potentials, but generates action potentials that are more frequent.

3.2. A brief review of brain basis of sentence processing

At this point, for the purpose of this study, we will describe briefly the basic processes to be considered in the characterization of brain basis of language comprehension. Friederici (2011, p. 1358) presents a description of sentence processing crucially differentiating three linguistic processing phases after an initial phase of acoustic-phonological analysis. In a first sentence-level processing phase, the local phrase structure is built based on word category information. In the second phase, syntactic and semantic relations in the sentence are computed. These involve the computation of the relations between the verb and its arguments, thereby leading to the assignment of thematic roles (*i.e.*, the analysis of who is doing what to whom). According to the investigator, once both semantic and syntactic information lead to the compatible interpretation, comprehension can easily take place. For example, the interpretation of an animate noun in sentence initial position as in “Mary cuts the flowers” is easy, as a person is a likely actor. For sentences in which semantic and syntactic information do not easily map, the processing system might need an additional third phase during which a final consideration and integration of the different information types is achieved, possibly including the context or world knowledge. During auditory sentence processing, these three different phases interact with linguistic prosody providing, for example, information about phrase boundaries relevant for syntactic processes. Linguistic prosody can also signal what is in the thematic focus of a sentence (indicated by stress in German and other Indo-European languages) and whether an utterance is a declarative sentence or a question (indicated by pitch in German and other Indo-European languages). This information is either essential or modulatory to the syntactic and semantic processes in a given sentence (FRIEDERICI, 2002). Friederici concludes by stating that the above description of the process of language understanding is certainly only a sketch of what psycholinguistics has to say about this very complex process, but it entails the basic processes that must be considered when characterizing the neural basis of language comprehension.

3.3. Brain´s language center

Based on different overviews (FRIEDERICI, 2002; HICKOK & POEPPEL, 2007; VIGNEAU et al., 2006), it is observed that the language-relevant cortex includes Broca's area in the inferior frontal gyrus (IFG), Wernicke's area in the superior temporal gyrus (STG), as well as parts of the middle temporal gyrus (MTG) and the inferior parietal and angular gyrus in the parietal lobe (see Figure 25). Spoken sentence comprehension requires a number of subprocesses to derive the meaning of a sentence from the auditory input, as there are acoustic-phonological, syntactic, and semantic processes (FRIEDERICI, 2011, p. 1362). We will focus on the prosodic process in this study.

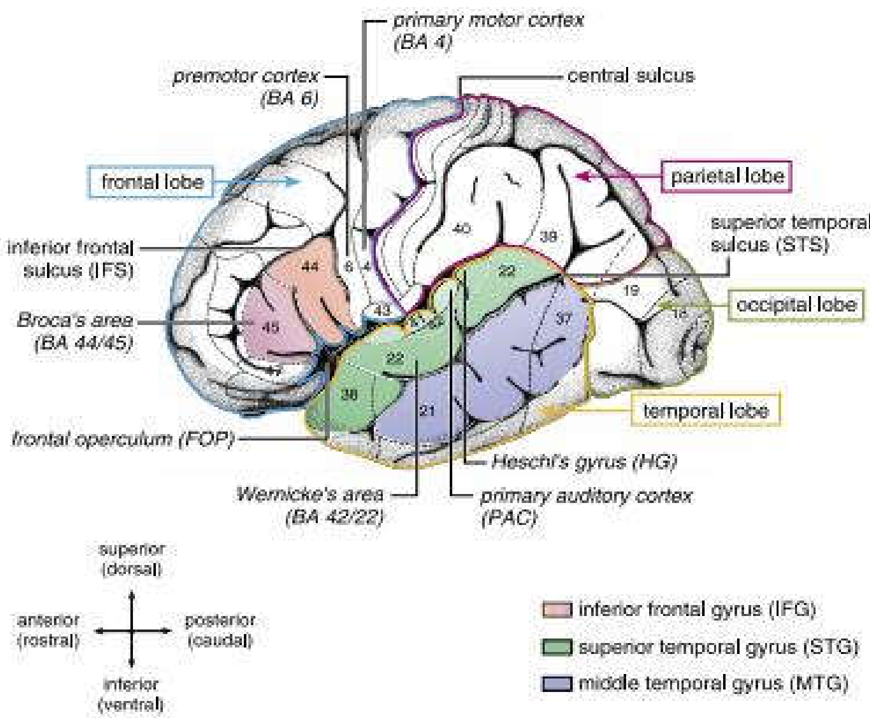


Figure 25: Anatomical and cytoarchitectonic details of the left hemisphere.
Source: Friederici (2011, p. 1359)

According to Friederici (2011, p. 1375), during the processing of spoken sentences, phonological information in addition to syntactic and semantic information must be processed. In addition to segmental information, the acoustic signal also conveys suprasegmental phonological information, called prosody. Two types of prosodic information are usually distinguished: emotional prosody and linguistic prosody. Emotional prosody is an extralinguistic cue signaling either the speaker's emotional state or emotional aspects of the content conveyed by the speaker. For this present thesis, we will focus on the brain basis of linguistic prosody only.

Prosodic information is mainly encoded in the intonational contour, which signals the separation of constituents (syntactic phrases) in a spoken sentence and the accentuation of (thematically) relevant words in a speech stream. By signaling constituent boundaries, this information becomes most relevant for sentence comprehension and the interpretation of who is doing what to whom. This can be observed from the example below, where # indicates the prosodic boundary (FRIEDERICI, 2011, p. 1375):

2) The man said # the woman is stupid.

3) The man # said the woman # is stupid.

The prosodic boundaries in these sentences are crucial for the interpretation as they signal the noun phrase to which the attribute "to be stupid" has to be assigned, either to the woman (2) or to the man (3). As the example shows, Friederici (2011, p. 1376) affirms that the prosodic information is relevant for syntactic processes, and there seems to be a close relation between prosody and syntax. Indeed, almost every prosodic boundary is also a syntactic boundary, while the reverse does not hold.

The brain basis of prosodic information has initially been investigated behaviorally in patients with cortical lesions in the left hemisphere (LH) and the right hemisphere (RH) (FRIEDERICI, 2011, p. 1376). While some studies came to the conclusion that linguistic prosody is mainly processed in the (RH) (BRÅDVIK et al., 1991; WEINTRAUB, MESULAM & KRAMER, 1981), others found that both LH and RH patients showed deficits in processing sentence level prosody (BRYAN, 1989a). However, when segmental information was filtered, thereby increasing the reliance on suprasegmental information, RH patients demonstrated significantly worse performance than LH patients (BRYAN, 1989a). These and other studies (PERKINS, BARAN & GANDOUR, 1996) suggest a relative involvement of the RH in processing prosodic information. The less segmental information there is available, the more dominant the RH (FRIEDERICI, 2011, p. 1376).

Friederici (2011, p. 1376) notes that neuroimaging studies provide support for the above observation. Processing of pitch information (intonational contour) is correlated with an activation increase in the RH, but can be modulated by task demands (SANTI & GRODZINSKY, 2010). An fMRI study that systematically varied the presence/absence of suprasegmental and segmental information reported changes in brain activation in the superior temporal and fronto-opercular cortices of the RH as a function of the presence/absence of information (MEYER et al., 2002, 2004) (see Figure 26). Right dorsolateral prefrontal cortex and right cerebellar activation were also reported for prosodic segmentation during sentence processing (STRELNIKOV et al., 2006). A study investigating sentences and word lists both with sentence prosody and word list prosody found bilateral activation in the anterior temporal cortex for syntactic and prosodic information, with the left being more selective for sentence structure (HUMPHRIES et al., 2005). In this latter study, clear RH dominance was found for prosody, but the authors point out that the activation in the right anterior temporal cortex may indicate prosody processing. Together, the studies suggest an involvement of the RH for the processing of intonational (pitch) information during sentence processing, but, in addition, indicate that the actual lateralization partly depends on task demands (JACKSON et al., 2004; SANTI & GRODZINSKY, 2010) and on the presence of concurrent segmental information (FRIEDERICI & ALTER, 2004; BRYAN, 1989).

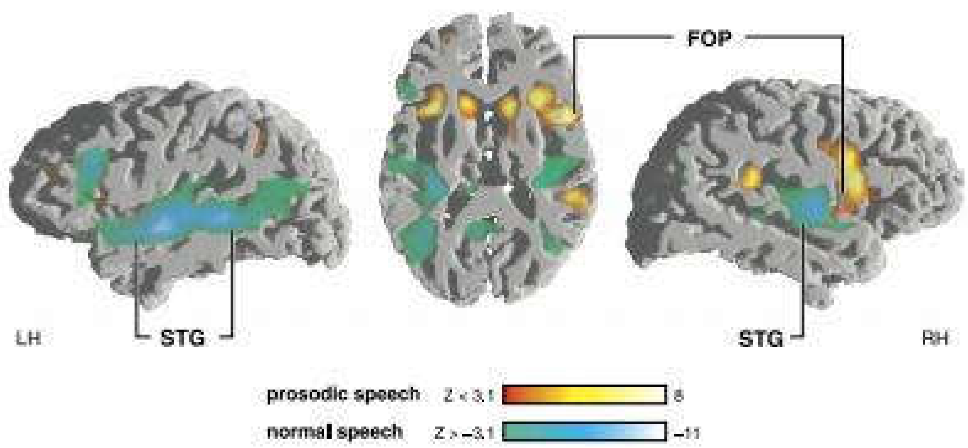


Figure 26: Brain activation during prosodic processes. Activation for sentence level prosodic information. Activation for prosodic speech (no segmental information, only suprasegmental information) vs. normal speech (segmental and suprasegmental information) is color coded in red-yellow, activation for normal speech vs. prosodic speech is color coded in green-blue. Source: Friederici (2011, p. 1376)

Friederici (2011, p. 1376) concludes by adding that the lateralization of linguistic prosody depends on the particular information prosody encodes in a given language. In tonal languages like, for example, Thai, pitch patterns are used to distinguish lexical meaning. When encoding lexical information, pitch is processed in the LH, similar to lexical information in non-tonal languages (GANDOUR et al., 2000). From this, it appears that the localization of language in the brain is determined by its function (lexical information) and not its form (pitch information). Only when intonation marks suprasegmental prosody, it is localized in the RH.

3.4. Temporal variations of language comprehension

In her extensive research, Friederici (2011, p. 1376) pointed out that Language undoubtedly unfolds in time. The data available from the fMRI studies on language processing do not provide the sufficient time resolution to capture this crucial aspect. However, from the 80s, Event-Related brain Potentials (ERPs) extraction technique was introduce in neurolinguistics researches (KUTAS & HILLYARD, 1980, 1984). According to Berkum (2004, p. 1), these early studies showed that ERPs can provide valuable information about the nature and time course of sentence comprehension, and in this regard, they hold a great deal of promise since they reflect neuronal activity related to language processing with millisecond accuracy (GOUVEA et al., 2010, p. 2). Moreover, those previous studies have shown that electrophysiological responses differ reliably in timing, amplitude, and scalp distribution as a function of different linguistic manipulations involving phonology, syntax and semantics, to name but a few (GOUVEA et al., 2010, p. 2). In the recent past, different language-related ERP components have been identified. ERPs have been allocated to different processes in the comprehension process presented in models of auditory sentence comprehension (*i.e.*, FRIEDERICI, 2011, p. 1377) (see Figure 27).

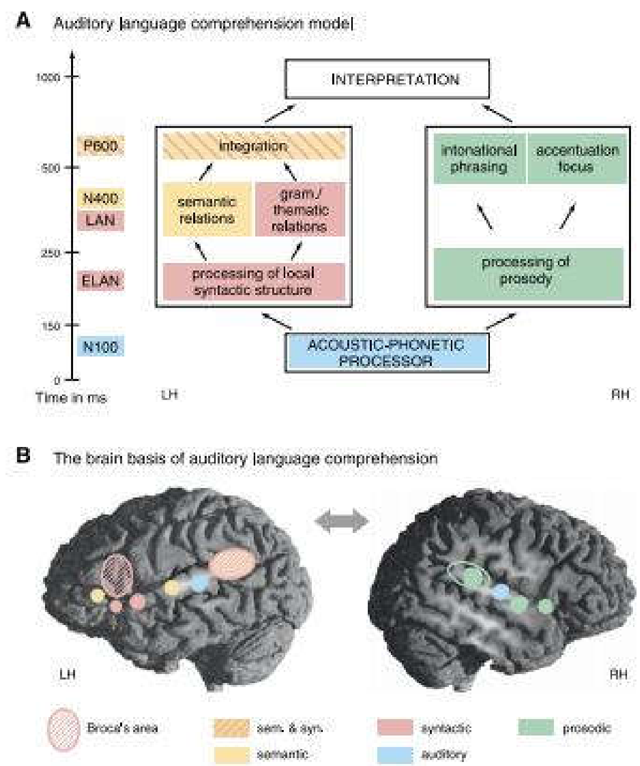


Figure 27: Model of auditory sentence comprehension.
Source: Friederici (2011, p. 1377)

We will briefly review these different language-relevant Event-Related brain Potential associated with auditory language comprehension, as Friederici (2011) describe them :

- N100: This component of ERPs is associated with acoustic-phonological process. It is the first ERP effect and it correlates with the identification of phonemes. It is a negative electrical potential of high amplitude around 100 ms after the stimulus onset (OBLESER, SCOTT & EULITZ, 2006). This ERP component is not specific to language, but reflects the discrimination of auditory categories and can thus be used to investigate aspects of vowel category perception (FRIEDERICI, 2011, p. 1378). The same holds for the mismatch negativity (MMN), an ERP component occurring shortly after 100 ms, which has been shown to reflect the discrimination of acoustic and phoneme categories (NÄÄTÄNEN et al., 1997). The N100 and the MMN have been located in or in the vicinity of the auditory cortex (DIESCH et al., 1996; POEPPEL et al., 1997), thereby indicating that these processes take place early during speech perception in this region (FRIEDERICI, 2011, p. 1378).
- N1-P2 complex: It is an obligatory ERP component that can reflect central auditory speech representation without active patient participation (MARTIN et al., 1998; OSTROFF, MARTIN & BOOTHROYD, 1998; SHARMA, DORMAN, 2000). This makes

the N1-P2 complex promising for assessing individuals who are affected by communicative or cognitive impairments by providing a window to the brain that is largely free of behavioral confounds such as memory and cognition (TREMBLAY et al., 2001). The N1 refers to the N100 ERP component, followed by a positivity, labeled (P2), with a peak latency of approximately 175 ms (WOOD & WOLPAW, 1982). Studies have shown that the N1-P2 complex reflects many of the spectral and temporal cues contained in spoken language that are important for speech perception (MARTIN et al., 1998; OSTROFF, MARTIN & BOOTHROYD, 1998; WHITING, MARTIN & STAPELLS, 1998)

- ELAN (Early Left Anterior Negativity): It is associated with initial syntactic process. It is the first sentence-level ERPs component correlating with the identification of the syntactic category of word (*i.e*, verb, noun, preposition, etc.) occurring in response to a word category violation 120-200 ms after word onset or after the part of the word which provides the word category information (*i.e.*, the inflection as in *refine* versus *refinement*) (FRIEDERICI & WEISSENBORN, 2007). Within the three-phase model of language comprehension (FRIEDERICI, 2002), this initial processing phase constitutes phase 1. In an EEG approach with patients with circumscribed brain lesions, it was found that the ELAN component is absent in patients with left frontal cortical lesions (including left basal ganglia lesions), but present in patients only suffering from left basal ganglia lesions, indicating that the left frontal cortex plays a crucial role in the generation of the ELAN (FRIEDERICI, VON CRAMON & KOTZ, 1999).

- N400 and LAN (Left Anterior Negativity): The component is related to the computation of syntactic and semantic relations. In a statement, to understand who is doing what to whom, semantic features (*i.e.*, animacy) as well as syntactic features (*i.e.*, subject-verb agreement, case marking, etc.) have to be processed. In the three-phase model of language comprehension this constitutes phase 2 (FRIEDERICI, 2002). Since the first ERP paper on language processing (KUTAS & HILLYARD, 1980), the N400 component of ERPs, a centro-parietal negativity around 400 ms, although it can extend from 250-500 ms, has been specifically correlated with the processing of semantic information. Thus the N400 is an indicator of 1) lexical processes, 2) lexical-semantic processes, 3) semantic contextual predictability, and 4) predictability due to world knowledge (FRIEDERICI, 2002, p. 24). Violations of subject-verb agreement (singular versus plural) in an inflecting language usually induce a LAN between 300 and 500 ms (German, (PENKE et al., 1997); Italian, (ANGRILLI et al., 2002); Spanish, (SILVA-PEREYRA & CARREIRAS, 2007)). In a fixed word order language such as English, an LAN is found less systematically (LAN in (OSTERHOUT & MOBLEY, 1995), but not in (KUTAS & HILLYARD, 1983; OSTERHOUT & NICOL, 1999)). It has been argued that the likelihood of observing the LAN increases with the amount of morphosyntactic marking in a given language. However, it is not the pure amount of morphosyntactic marking that determines the presence of the LAN, but whether this information is crucial for the assignment of syntactic roles. In other words, whenever morphosyntactic marking is crucial for the assignment of grammatical relations in a sentence, an LAN is observed (FRIEDERICI, 2011, p. 1381).

- P600: It is related the integration and interpretation phase in sentence perception processing. Friederici (2002) proposed that this last phase (phase 3) represents a phase during which processes of syntactic reanalysis and repair take place and that these processes are reflected in a late centro-parietal positivity occurring around 500-600 ms after the stimulus, and last for hundreds of milliseconds (HAGOORT et al., 2000, p. 286; GOUVEA et al., 2010, p. 7). Initially, it was taken to reflect syntactic processes in general (HAGOORT et al., 1993), processes of syntactic reanalysis and repair (FRIEDERICI et al, 1996), or the difficulty of syntactic integration (KAAN et al., 2000). However, later studies found the P600 to vary not only as a function of syntactic variables, but also to reflect the interaction of syntactic and semantic anomaly at the sentence level (HACKETT, 2011; KUPERBERG et al., 2006), suggesting that the P600 might reflect sentence-level integration processes of syntactic and semantic information.

- CPS: This component reflects prosodic processing. Friederici (2011, p. 1383) reports that the processing of auditorily presented sentences not only requires the processing of semantic and syntactic information but, moreover, the processing of prosodic information. Steinhauer et al. (1999) first found an electrophysiological correlate for the processing of sentence-level prosodic information in an ERP study on the processing of German sentences which either contained one intonational phrase boundary (*IPB*) or two. At the *IPB*, the ERPs revealed a centro-parietally distributed positive shift, around 500 ms after *IPB* onset. This ERP response was labeled the Closure-Positive-Shift (CPS). The CPS was found in studies of several other languages, such as Dutch (KERKHOFS et al., 2007; BÖGELS et al., 2010), Japanese (WOLFF et al., 2008), Chinese (LI & YANG, 2009), English (ITZHAK et al., 2010), French (GILBERT, BOUCHER & JEMEL, 2010), and Korean (HWANG & STEINHAUER, 2011). The CPS is not triggered by the pause at the *IPB* per se; rather, pitch variation and the lengthening of the syllable immediately preceding the pause are sufficient to evoke the component. This was demonstrated in an experiment in which the pause at the *IPB* was deleted (STEINHAUER et al., 1999). Interestingly, the latter presumption has not been verified for young children. In infants and toddlers, neural responses to boundary processing are not elicited when the pause is deleted, but only when the pause is present (MÄNNEL & FRIEDERICI, 2009, 2011). However, in older children with sufficient syntactic knowledge, pitch variation and pre-final syllable lengthening alone can elicit a CPS, just as in adults (MÄNNEL & FRIEDERICI, 2011). This suggests that the pause initially serves as a target cue to structure the speech input, but that it is not needed for intonational phrasing once sufficient knowledge about prosodic and syntactic structure are acquired (FRIEDERICI, 2011, p. 1383). Additional experiments with adults showed that the CPS can also be elicited when only prosodic information of a sentence is delivered (*i.e.*, when segmental information is not available). Under this condition, where the investigators used experimental material presenting with decreasing semantic, syntactic, and phonemic information (*i.e.*, jabberwocky sentences, in which all content words were replaced by meaningless words; pseudoword sentences, in which all function and all content words are replaced by meaningless words; and delexicalized sentences, hummed intonation contour of a sentence removing all segmental content), the CPS is reported over the right hemisphere (PANNEKAMP et al., 2005). Regardless of pitch cues or meaningful linguistic forms, the CPS was as well evoked specifically by chunks of speech marked by lengthening (GILBERT et al., 2010, 2012, 2015). Moreover, the CPS is reported for sentence reading triggered by a comma indicating a syntactic phrase boundary (STEINHAUER & FRIEDERICI, 2001; STEINHAUER, 2003; KERKHOFS et al., 2008). Thus the CPS can be regarded as an ERP component that is correlated with prosodic phrasing both when realized explicitly in the speech stream and when realized covertly in written sentences (FRIEDERICI, 2011, p. 1383).

It should be noted at this point that some of these ERP components are tied together. In an experiment for instance, to a large extent, N400, P600 and CPS could be related and might be difficult to dissociate. This is due to their temporal characteristics, but also due to experimental designs. For example, semantic violations or syntactic violations are often used to probe linguistic processing. The next subsection reviews briefly some previous ERP studies. We focus on studies in PB.

3.5. A brief review of ERPs studies in BP.

Using the extraction of ERPs technique, Lage et al. (2008) investigated the neurophysiology of "subject" merge, as external argument of the verb, and tested the bottom-up hypothesis of the sentence derivation, which postulates that first the verb would merge to its complement, and then the complex verb-complement would merge with the subject. Thus, the order of the derivation course, that is, of the cognitive tasks in the computation of language, would be different from the linear order of the constituents in the sentence. In their experimental sentences (see example 4 and 5), they manipulated the subject's semantic congruence through its [± animated] trait. That way, they could investigate the linguistic phenomena from the computation of the verb, up to the interpretation of the sentence as a whole.

(4) *O menino chutou a bola* (the boy kicked the ball)

(5) **A cadeira chutou a bola* (the chair kicked the ball)

Twenty-nine normal subjects (15 males), students of the Federal University of Rio de Janeiro, native speakers of BP, were recruited. Considering an experimental paradigm, sentences were presented to the subjects and the EEG signals were collected and subsequently ERPs signals were extracted. The findings revealed classical ERP components (including N400 and P600). The interpretation of the results confirmed the bottom-up hypothesis of the sentence derivation and this has help to further understand about the course of the syntactic derivation and the dynamic of interaction among micromodules involving language cognition.

Soto et al. (2015) studied the sensitivity of the N400 to early information from outside of the verb-complement scope (an adjunct in the left periphery of the sentence). Using supporting adjunct information as a condition, the investigators tried to unveil the sensitivity of the N400 to data that is not part of the core structure of the event. They advanced the hypothesis that the information in the adjunct position would not be taken into account in the same time-frame of the event´s information. The experimental stimuli per condition are illustrated below in example 7.

(7)

Congruous Supportive-Context: “*Até sem capacete, João dirige ↑ a moto feito louco”*

“Even without a helmet, João drives the motorcycle like a madman”

Congruous Non-Supportive Context: *“Todos os dias, João dirige ↑ a moto feito louco”*

“Everyday, João drives the motorcycle like a madman”

Incongruous Supportive-Context: *“Até sem capacete, João dirige ↑ a pera feito louco”*

“Even without a helmet, João drives the pear like a madman”

Incongruous Non-Supportive Context: *"Todos os dias, João dirige ↑ a pera feito louco"*
"Everyday, João drives the pear like a madman"

Twenty-one (11 females) students participated in the experiment at the Federal University of Rio de Janeiro. The findings showed that N400 effects were not modulated by the contextualization, given that incongruency effects are similar for contextualized and non-contextualized sentences, but rather verb-complement integration affects N400 amplitudes. The results successfully displayed the specific nature of the N400 wheeling around the verb-complement relations. Information related to the adjunct did not affect the N400 component, as advanced in the hypothesis.

Taking into consideration differences in syntactic configurations underlying the verb-complement merge operation, Franca et al. (2004) investigated three series of sentences containing incongruous and congruous merges. The aim was to relate syntactic specificities to the resulting ERP morphologies. Conditions tested required three types of computations: local merge, local merge depending on inheritance of semantic properties from an antecedent and merge performed at distance (WH- displacement). A total of 240 experimental sentences (80 for each condition) generated (see example 8).

8) <u>Example of experimental sentences in Series 1</u>

Congrous: *Minha professora leu um livro.*
My teacher read a book.

Incongruous: *Meu primo rasgou a geladeira.*
My cousin tore the fridge.

<u>Example of experimental sentences in Series 2</u>

Congruous: *Ele lavou a maçã e secou-a.*
He washed the apple and dried it.

Incongruous: *Ela abriu as janelas e comeu-as.*
She opened the windows and ate them.

<u>Example of experimental sentences in Series 3</u>

Congruous: *Que quadro ela pintou?*
What picture she painted?

Incongruous: *Que cor ela bebeu?*
What color she drank?

Following an experimental paradigm, the stimuli were presented to twenty-five students volunteers (13 males). The EEG signals were then collected, and ERPs signal extracted. The findings revealed that Series 1 involving strictly local computations resulted in classic parietal N400s, whereas the inheritance stimuli, in Series 2, elicited two peaks in the parietal and central region ERPs. Series 3—WH-displacement— presented earlier and more salient cortical responses (including N400 and P600). The different ERP morphologies resulting from each condition are consistent with a model in which language processing results from task-specific computations involving different neurological subsystems.

This present thesis will focus on the CPS component of ERPs. In the following section, we will discuss methodological approach related to the extraction of this component and present some researches on ERP correlates of prosodic processing.

3.6. CPS (Closure-Positive-Shift)

3.6.1. The CPS: a brief review of methodological approach

Previous ERP studies led to a general profile of the CPS. In terms of scalp distribution, the CPS is found bilaterally and is largest at midline electrodes (BÖGELS et al., 2011, p. 428). Some studies reported an extension to anterior electrodes (*i.e.,* BÖGELS et al., 2010; PANNEKAMP et al., 2005). Itzhak et al. (2010) also reported a fronto-central CPS distribution. The CPS generally starts around or even before pause onset (STEINHAUER, 2003), although Kerkhofs et al. (2007) found a later onset. Its offset appears to be triggered by the onset of the word immediately following the pause and it lasts around 500-700 ms (PAUKER et al., 2011).

In an effort to establish the CPS as a distinct ERP component, especially responsive to prosodic boundaries (henceforth *PB*), alternative accounts have been considered and rejected. First, previous studies (STEINHAUER, 2003; BÖGELS et al., 2010) have suggested that the CPS might be the P2 obligatory ERP component in response to the onset of the word immediately following the pause. This interpretation was proven not to be reasonable, since the CPS starts well before the average pause offset. Moreover, when the investigators applied a low-pass filtering of 1 Hertz (Hz), P2 components disappeared, while the CPS remained present. Second, despite a similarity in polarity, the CPS does not appear to be a form of the P600, because it is evoked in correct and unambiguous sentences. It remains possible that the CPS and the P600 share common subprocesses (STEINHAUER & FRIEDERICI, 2001). These findings of previous studies (STEINHAUER, 2003; BÖGELS et al., 2010) support that the CPS is a response to the *PB* as a whole. It remains unclear which aspects of the *PB* are necessary for the elicitation of a CPS. In the auditory domain, since the pause is apparently not necessary, pre-final syllable lengthening and or boundary tone remain the acoustic cues responsible for eliciting a CPS. On the other hand, when prosodic phrasing is realized covertly in sentence reading, the CPS is triggered by a comma. Another essential aspect is the methodological approach for the CPS extraction.

ERPs are generally computed by taking the average of several epochs of the EEG time-locked to the onset of the event of interest. In the case of the CPS, it is not yet clear which elements of the *PB* elicit the CPS and thus it is not easy to determine an adequate time-locking point for the CPS (BÖGELS et al., 2011). Steinhauer et al. (1999) avoided this problem by time-locking the ERPs to the onset of the sentence. The (approximate) timing of the CPS was then determined relative to the average onset of the pause across all the experimental sentences used in the experiment. A disadvantage of this method is the considerable variation between experimental items in the onset of the pause (STEINHAUER, 2003, p. 151). In order to address this issue, Kerkhofs et al. (2007) time-locked the ERPs to the onset of the pause. Since the CPS is not specifically elicited by pause (STEINHAUER, ALTER & FRIEDERICI, 1999), pre-final syllable lengthening and boundary tone – two prosodic cues that are reportedly associated with boundary marking – should be considered as well. But these cues appear before pause onset. Bögels et al. (2011) investigated this methodological problem in detail by comparing different time-locking points. In addition to the two methods described above, they tried to establish the onset of the *PB* by acoustic analyses. These analyses revealed that the boundary tone started on the last word immediately preceding the pause, and that pre-final syllable lengthening was clearly present only from the onset of the last stressed syllable before the pause. Bögels et al. (2011) thus considered the onset of the last stressed syllable as the “onset of the prosodic boundary”, and as the theoretically most appropriate time-locking point for the CPS analysis. The CPS time-locked to the onset of the last stressed syllable before the pause appears to have a less broad and more focal shape with a sharper peak as compared to the CPS extracted with the other two time-locking points. This suggests that pre-final syllable lengthening and boundary tone would play an important role in the elicitation of the CPS (BÖGELS et al., 2011, p. 429).

The degree to which acoustic and linguistic cues determine the elicitation of the CPS has yet to be established (PETER et al., 2014, p. 2). The majority of CPS studies supports the idea that acoustic prosodic cues are primarily responsible for the generation of the CPS (BROUWER, FITZ & HOEKS, 2012), while linguistic cues modulate its amplitude and scalp topography (KERKHOFS et al., 2007). Also, Kerkhofs et al. (2007) argued that a larger CPS is evoked by a less expected *PB*, which is therefore more salient. This indicates that the CPS amplitude depends on the salience of prosodic boundary markers (KERKHOFS et al., 2008). According to Li and Yang (2009), although the pause is not a required factor to evoke the CPS, it may modulate its onset latency and amplitude. Steinhauer (2003) reported that the CPS amplitude and duration are larger in auditory than visual language presentation and seem to correlate positively with the degree to which, during silent reading, phonological representations (*i.e.*, listening to the "inner voice") are activated.

3.6.2. A brief review of studies on CPS component of ERPs.

The CPS was first observed by Steinhauer et al. (1999) in a research of three experiments investigating brain potentials related to prosodic cues in natural speech processing. The material consisted of 144 German filler sentences and 48 experimental sentence pairs such as 9a and 9b, where the bracketing indicates the respective intonational phrases (IPhs) as described below:

(9a) [*Peter verspricht Anna zu arbeiten*] IPh1 [*und das Büro zu putzen*] IPh2

Peter promises Anna to work and to clean the office.

(9b) [*Peter verspricht*] IPh1 [*Anna zu entlasten*] IPh2 [*und das Büro zu putzen*] IPh3

Peter promises to support Anna and to clean the office.

Using a cross-splicing technique, the researchers merged the acoustic signals of the first part of (9b) and the second part of (9a) between "*Anna*" and the infinitive marker "*zu*" ("to") of the second verb in each of the 48 sentence pairs. An Amplitude normalization protected against detectability of the signal manipulation at the splicing point. This resulted in a third condition (9c) with a mismatch between prosodic information (Methods) and syntactic constraints (that is, the intransitivity of the verb "*arbeiten*"):

(9c) * [*Peter verspricht*] IPh1 [*Anna zu arbeiten*] IPh2 [*und das Büro zu putzen*] IPh3

Peter promises to work Anna and to clean the office

The prosodic inappropriateness of 9c becomes obvious only when the intransitive verb "*arbeiten*" is encountered. At this point, the sentence should initially be perceived as "Peter promises to work Anna", which is certainly ungrammatical.

The speech signals were produced by a female native speaker of standard German and recorded in a soundproof chamber and then digitized (44.1 kHz, with a bit depth of 16 bits per sample). The participants were twenty students in each of the first two ERP experiments, and sixteen in the third experiment. All 56 subjects were right-handed as measured by the Edinburgh Handedness Inventory (OLDFIELD, 1971), and without hearing or neurological disorders. The stimuli were presented to the subjects following an experimental paradigm. EEG signals were recorded, and ERPs signal extracted. Steinhauer et al. (1999) aimed to test whether prosodic cues in spoken language are immediately used by the listener to solve syntactic ambiguities that systematically result in initial misunderstandings during reading, and to determine whether these prosodic influences can be monitored on-line by ERP measures. In the findings, not only did they demonstrate that the prosodic information was sufficient to reverse syntactic parsing preferences, but the researchers also found that prosodic boundaries are associated with a large positive-going waveform, which they labeled the closure positive shift (CPS) (see Figure 28). This component did not depend on the presence or absence of a pause acoustically interrupting the stream of speech input. They conclude that the CPS may be associated with processes that serve to structure the mental representation of the speech signal and to prepare the further analysis of subsequent input.

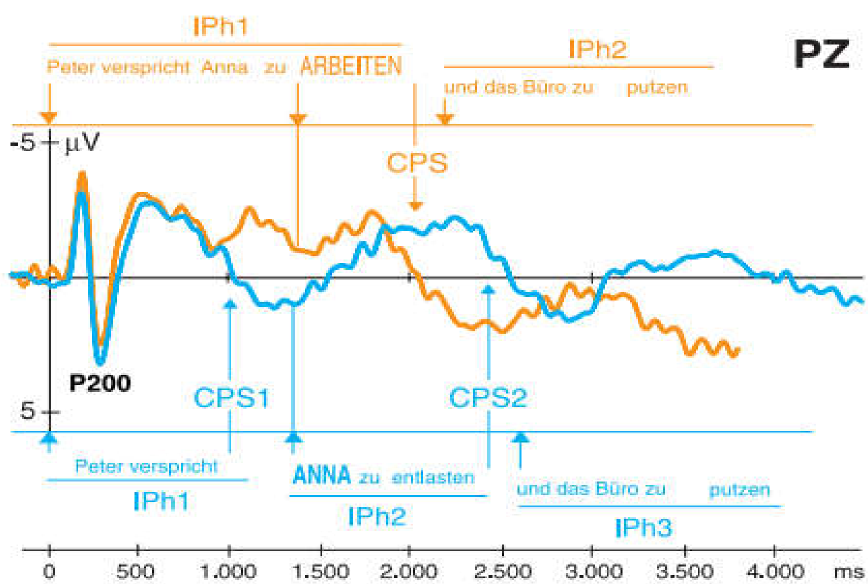


Figure 28: Closure positive shift. Grand-average ERPs of both experiments ($n = 40$) at the PZ electrode. The waveforms of conditions A (orange) and B (blue) are superimposed. The word onsets of the sentence examples are aligned to the time axis. Both conditions evoke closure positive shifts at their respective IPh boundaries. Only one shift is observable in condition A, following the second verb "*arbeiten*", whereas two such shifts occur in condition B, before "Anna" and after the second verb "*entlasten*".
Source: Steinhauer et al. (1999, p. 4)

Kerkhofs et al., (2007) investigated the interaction between syntax and prosody in speech. The authors argued that in locally syntactic ambiguous sentences, the detection of a syntactic break necessarily follows detection of a corresponding prosodic break, making an investigation of the immediate interplay of syntactic and prosodic information impossible when studying sentences in isolation. Kerkhofs et al., (2007) solved the problem by embedding sentences in a discourse context that induces the expectation of either the presence or the absence of a syntactic break right at a prosodic break. In two separated experiments, the researchers compared the ERPs of acoustically identical sentences in those two contexts. The participants were sixty (44 females) undergraduate adult Dutch students from the University of Nijmegen. All were right-handed; hand dominance was assessed by an abridged version of the Edinburgh Inventory (OLDFIELD, 1971). The material consisted of 240 small stories of four to five sentences, 6 starter items and 14 training items. The material was recorded by a female student of Dutch who was knowledgeable on Dutch prosody. The auditory stimuli were then created from the recording and presented to the participants. EEG signals were recorded, and ERP signals extracted. The findings revealed a CPS in response to the occurrence of a prosodic break as compared to sentences without a prosodic break. When the prosodic break coincided with a syntactic break, the CPS was significantly smaller than when the prosodic break did not coincide with a syntactic break. The observation is presented in Figure 29. The investigators concluded that their finding shows that syntactic information and prosodic information interact, and crucially, that they interact immediately at the point at which the prosodic information becomes available.

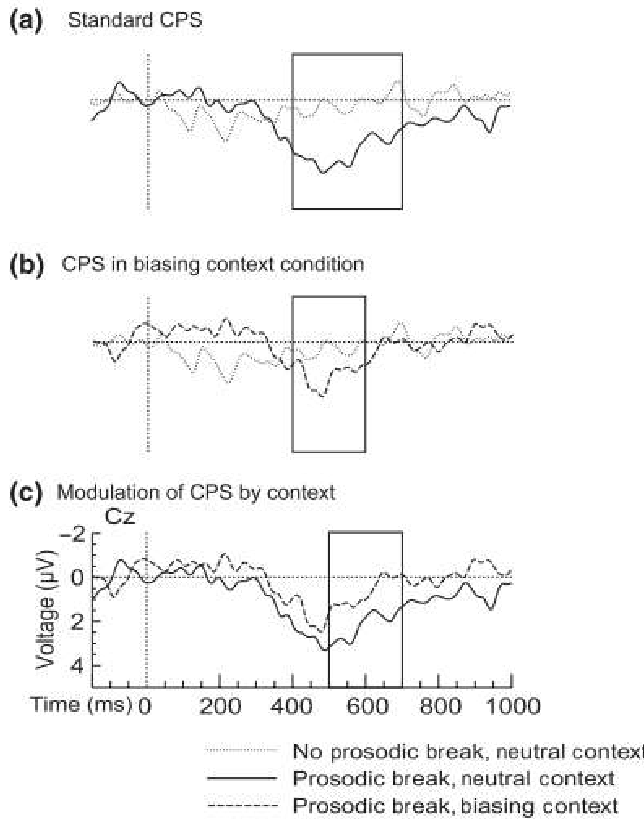


Figure 29: Modulation of the closure positive shift (CPS) as in Kerkhofs et al. (2007). Grand averages for the central midline electrode (Cz) time-locked to pause onset. Panel A shows a standard CPS for sentences preceded by a neutral context. Panel B shows a standard CPS for sentences preceded by a biasing context (eliciting an expectation for a syntactic break at the prosodic break (PB)). Panel C shows the CPS modulation as a result of context. The CPS is smaller for the biasing context (syntactic break expected) than for the neutral context (no syntactic break expected).
Source: Bögels et al. (2011, p. 10)

In a relatively recent research, Peter et al. (2014) investigated whether the CPS was elicited by acoustic cues at phrase boundaries in English when, in an experiment, participants listened passively to sentences with either early or late phrase boundaries. Twenty-four volunteers (13 females) were recruited. They were native speakers of English with no hearing disorders and were strongly right handed as recommended in the literature (OLDFIELD, 1971). Speech stimuli were 80 pairs of sentences with either an early phrase boundary (EPhB) or a late phrase boundary (LPhB). Both the early and late phrase boundary sentences contained the same words, but the presence of phrase boundary was different between them. See examples 10 and 11 of experimental sentences below (# indicates a phrase boundary):

10) Because John studied # the subject matter is clearer now (EPhB).

11) Because John studied the subject matter # it is clearer now (LPhB).

The sentences were spoken by an adult male speaker of Australian English who did multiple repetitions of the sentences at a normal rate, which were recorded using a unidirectional microphone, and digitized at 44.1 kHz with a bit depth of 16 bits per sample. The recorded sentences were analyzed using Praat software for duration, frequency and intensity measurements. From the pool of 80 sentence pairs, 48 pairs of experimental sentence were selected as the stimuli. This selection was done so that the phrase boundary occurred at approximately the same time for all early phrase boundary sentences (M = 1225 ms, SD = 52 ms) and for all late phrase boundary sentences (M = 1986 ms, SD = 112 ms). None of the sentences were acoustically manipulated, since it would affect the naturalness of the stimuli. Stimulus example waveforms are shown in Figure 30.

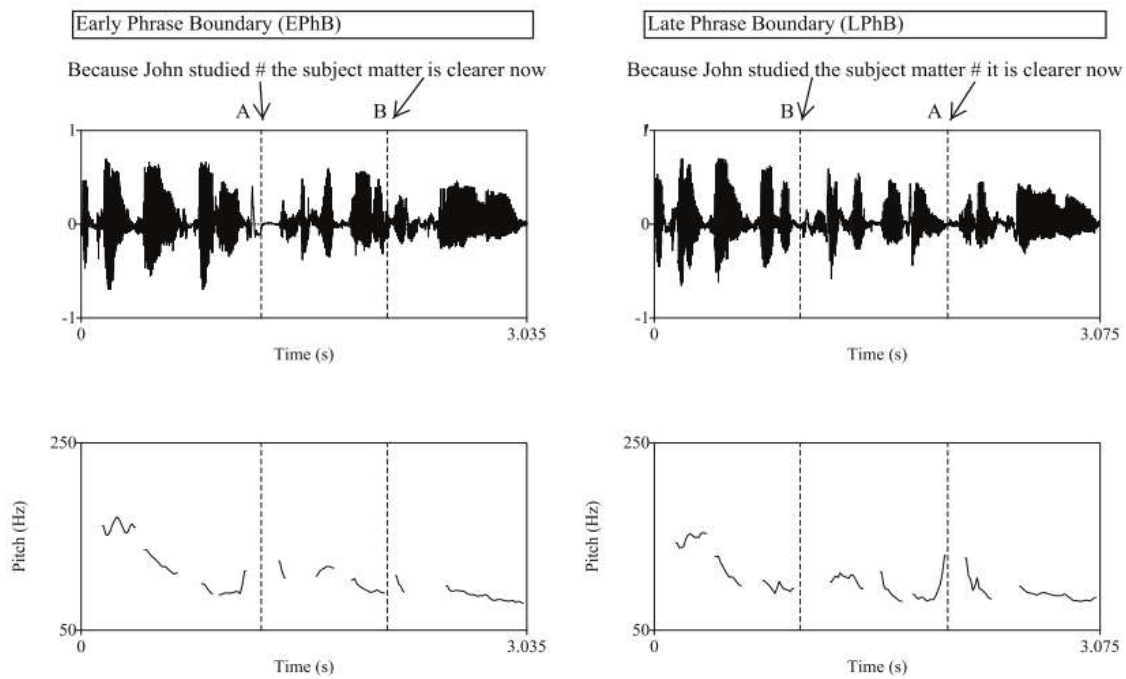


Figure 30: Waveform and fundamental frequency (F0) contour of example sentences with early phrase boundary (left) and late phrase boundary (right). The arrows show the place where the additional triggers were placed.
Source: Peter et al. (2014, p. 3)

They also created 96 filler sentences that did not include a phrase boundary and presented approximately the same length as the experimental sentences. Two examples 12 and 13 of filler sentences are shown below:

12) The reporters were frustrated by the politician’s answers to their questions.

13) The tourists were extremely dispirited before they reached the Himalayas.

The experimental and filler sentences were presented in pseudorandom order, with the constraint that the same sentence was not presented twice in a row. The stimuli were divided into two blocks of 96 sentences each and presented to both ears via headphones, with an inter-stimulus-interval of 2.5 seconds. In the EEG recording, the subjects were told that they should ignore the sounds in the headphones and focus their attention on the silent video on the computer screen. The video did not include subtitles because there is evidence that commas in the written text generate a CPS-like component (STEINHAUER & FRIEDERICI, 2001). While participants were watching the video, and ignoring the sentences, EEG signals were recorded continuously until all stimuli in the blocks have been presented. The EEG data was then processed, and ERPs signal extracted. Based on their the results, Peter et al. (2014) observed a CPS at both early and late phrase boundaries, confirming that the component can be elicited under passive listening conditions. However, the latency, amplitude, and scalp distribution of these passive CPS in English sentences differed to active CPS measured in non-English sentences in previous studies. They concluded that acoustic cues at the phrase boundaries in English are sufficient to elicit the CPS and suggest that different processes might be involved in the generation of the CPS in active and passive conditions. Grand averaged ERPs to early phrase boundary and late phrase boundary sentences at the representative Cz electrode are shown in Figure 31:

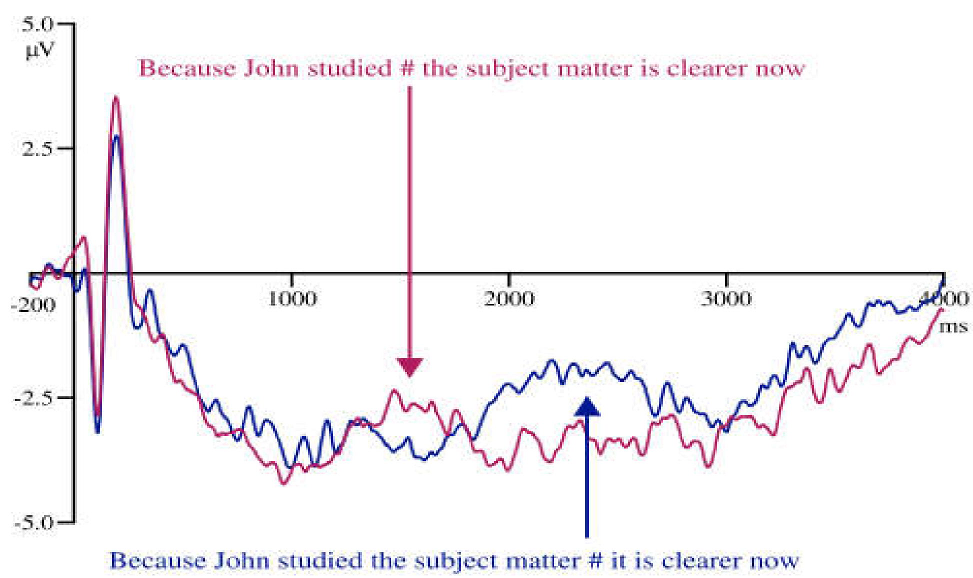


Figure 31: Grand averaged ERPs for sentences with early phrase boundary (red) and late phrase boundary (blue) at Cz. ERPs are time locked to the onset of the sentence and epochs cover the whole sentence.
Source: Peter et al. (2014, p. 6)

To our knowledge, the present study is the first to investigate the CPS component in Brazilian Portuguese and the first to compare this ERP component at the boundaries of the two highest prosodic constituents. The following section presents the mythological approach adopted in this study.

4. METHOD

4.1. Ethics statement

The present thesis followed ethical precepts recommended for research with human and procedures were carefully and duly observed. The Ethics Committee for Research at Federal University of Alagoas approved the experimental methods used in this study (approval number: CAAE/ 53319416.6.0000.5013). Written informed consent was obtained from all the participants.

4.2. Material

The experimental material used in this study consists of statements in Brazilian Portuguese constructed with particular syntactic patterns that yielded different boundaries in the language´s prosodic hierarchy. Each statement contains an *IPB* and *UB*. Three versions of each statement were created. The first version (Type A) was the basis for the other two versions (Type B and Type C) as follows below in example (14) (# stands for *IPB*, **#*** for "*no IPB*", **%** for *UB* and %* for "*no UB*"):

(14) Type A:

Assim que Paula viu sua ***aMIga*** **#** *ela fechou a* ***jaNEla*** **%** *Foi abrir a porta.*

(As soon as Paula saw her friend, she closed the window. She then opened the door)

Type B:

Assim que Paula viu sua ***aMIga*** **#*** <u>*de infância*</u> **#** *ela fechou a janela* **%** *Foi abrir a porta.*

(As soon as Paula saw her childhood friend, she closed the window. She then opened the door)

Type C:

Assim que Paula viu sua amiga **#** *ela fechou a* ***jaNEla*** **%*** <u>*da sala*</u> **%** *Foi abrir a porta.*

(As soon as Paula saw her friend, she closed the living room window. She then opened the door)

It is noteworthy that analyses in this present study only focused on the "target edges" characterized above in example (14) in bold italic font. In Type A, the boundary after the subordinate clause coincides with an *IPB* and the boundary after the main clause with *UB*. In

Type B, the sentence portion corresponding to the subordinate clause (in Type A) is not followed immediately by an *IPB* – "no *IPB"* (*NIPB*). And in Type C, the sentence portion corresponding to the main clause (in Type A) is not followed immediately by an *UB* – "no *UB"* (*NUB*). The last words of the subordinate clause and main clause were always a trisyllabic verb complement (indicated in bold italic font) named "target words", presenting with a paroxytone stress pattern (indicated in uppercase in the penultimate syllable). The three versions of the experimental material only differed with respect to the adnominal adjuncts (indicated by the underlined words) added to subordinate clause in Type B and to the main clause in Type C. A total of 134 experimental items were created. In terms of number of syllables, mean value of length of the subordinate clause was M= 10 syllables, SD= 0.75, and for main clause, M= 8 syllables, SD= 0.89.

In addition, 120 fillers were constructed. The fillers were statements similar in length to the experimental items. They also presented three types (40 statements of each type), each of them characterized by different syntactic patterns, as follows below in example (15) (**#** stands for *IPB* and **%** for *UB*):

(15) Type F_A:
Quando viram o pescador chegando **#** *lhe ajudaram a tirar o barco da água.*

Type F_B:
O prefeito caiu e fraturou a perna direita durante a festa de fim de ano.

Type F_C:
Berto revelou o segredo da família no tribunal **%** *O pai tinha outra esposa.*

To ensure the naturalness and acceptability of the experimental items, we conducted a norming study with a group of 30 students, all of them native speakers of Brazilian Portuguese. A total of 402 experimental items was used in the norming study. They were classified into the three types of statements (A, B and C) described above. In order to avoid an effect of familiarity by presenting similar experimental items to the same participant, we divided the participants into three groups of ten individuals and used a Latin square design to create three lists of materials.

The norming study was conducted online using the *Qualtrics* platform where materials´ acceptability was judged using a numerical scale or categorical labels (a Likert-type scale), which could be later converted into numbers (SCHMIDT-NIELSEN, 1992).

Participants were instructed to assign to each of the statements a numerical scale of 1 (less acceptable) to 7 (more acceptable). They started with practice trials before the actual norming experiment. Mean value of the numbers obtained from the numerical scale for each of the 134 sets of statements was calculated and then we reported the Grand Mean (mean of all 134 means) which was M= 6, SD= 0.39. This showed that, to a large extent, the statements were considered to be acceptable. Based on the results of the norming experiment, a total of 120 sets of experimental items that received the highest rate of acceptability was selected for our ERP experiment.

4.3. Stimuli

4.3.1. General description

A male professional announcer and native speaker of Brazilian Portuguese recorded the speech stimuli using an omnidirectional microphone in adequate acoustic conditions (an acoustic cabin) with a normal speech rate (M = 5.589 syllable per second (syll/s), SD= 0.4). This speech rate was measured by dividing the number of syllables in the stimulus by its duration (excluding the pause duration). The result corroborates previous findings which reported average speech rate ranging from 3.2 to 5.5 Syll/s for a native fluent speaker of Brazilian Portuguese (OLIVEIRA, 2000; MARTINS et al., 2008).

The announcer was instructed to repeat each statement at least three times, so we could choose the best recording possible for the experimental items and fillers. The recording was digitized at 44100 Hz with a bit depth of 16 bits per sample.

4.3.2. Acoustic analysis

Acoustic analysis was conducted using Praat software (BOERSMA & WEENINK, 2018) to first verify what prosodic cues were associated with the *IPB* and *UB* (in Type A) as compared to *NIPB* (in Type B) and *NUB* (in Type C). Secondly, we verified the acoustic differences between *IPB* and *UB*.

Figure 32, Figure 33 and Figure 34 illustrate the annotation that was created in Praat for all the material that was used in the study. Tier 1 is used for the “target prosodic edges” (*IPB, NIPB, UB* and *NUB*). Tier 2 is for the orthographic transcription of the stimulus. Tier 3 is for the three syllables of the “target words”. The three syllables immediately preceding *IPB* were categorized as follows: (i) *Pre_IPB*, pre-stressed syllable; (ii) *Str_IPB*, stressed syllable; (iii) *Pos_IPB*, post-stressed syllable. Those preceding *NIPB* as follows: (i) *Pre_NIPB*, pre-stressed syllable; (ii) *Str_NIPB*, stressed syllable; (iii) *Pos_NIPB*, post-stressed syllable. The three syllables immediately preceding *UB* were categorized as follows: (i) *Pre_UB*, pre-stressed syllable; (ii) *Str_UB*, stressed syllable; (iii) *Pos_UB*, post-stressed syllable. Those preceding *NUB* as follows: (i) *Pre_NUB*, pre-stressed syllable; (ii) *Str_NUB*, stressed syllable; (iii) *Pos_NUB*, post-stressed syllable. Tier 4 is for the vowel nuclei of the three syllables of the “target words”. The vowel nuclei, considering the syllables to which they belong, were categorized as follows: (i) *Pre_IPB_VN*, vowel nucleus of pre-stressed syllable; (ii) *Str_IPB_VN*, vowel nucleus of stressed syllable; (iii) *Pos_IPB_VN*, vowel nucleus of post-stressed syllable. Those preceding *NIPB* as follows: (i) *Pre_NIPB_VN*, vowel nucleus of pre-stressed syllable; (ii) *Str_NIPB_VN*, vowel nucleus of stressed syllable; (iii) *Pos_NIPB_VN*, vowel nucleus of post-stressed syllable. The three syllables immediately preceding *UB* were categorized as follows: (i) *Pre_UB_VN*, vowel nucleus of pre-stressed syllable; (ii) *Str_UB_VN*, vowel nucleus of stressed syllable; (iii) *Pos_UB_VN*, vowel nucleus of post-stressed syllable. Those preceding *NUB* as follows: (i) *Pre_NUB_VN*, vowel nucleus of pre-stressed syllable; (ii) *Str_NUB_VN*, vowel nucleus of stressed syllable; (iii) *Pos_NUB_VN*, vowel nucleus of post-stressed syllable. Tier 5 is for the vowels of three syllables of the “target words”. The vowels, considering the syllables to which they belong, were also categorized as follows: (i) *Pre_IPB_V*, vowel of pre-stressed syllable; (ii) *Str_IPB_V*, vowel of stressed syllable; (iii) *Pos_IPB_V*, vowel of post-stressed syllable. Those preceding *NIPB* as follows: (i) *Pre_NIPB_V*, vowel of pre-stressed syllable; (ii) *Str_NIPB_V*, vowel of stressed syllable; (iii) *Pos_NIPB_V*, vowel of post-stressed syllable. The three syllables immediately preceding *UB* were categorized as follows: (i) *Pre_UB_V*, vowel of pre-stressed syllable; (ii) *Str_UB_V*, vowel of stressed syllable; (iii) *Pos_UB_V*, vowel of post-stressed syllable. Those preceding *NUB* as follows: (i) *Pre_NUB_V*, vowel of pre-stressed syllable; (ii) *Str_NUB_V*, vowel of stressed syllable; (iii) *Pos_NUB_V*, vowel of post-stressed syllable. Tier 6 is for the number of syllables in the stimulus. Finally, Tier 7 is for the syntactic structure of the stimulus. The subordinate clause, main clause, independent clause, “interval of silence” marking *IPB* and “interval of silence” marking *UB* were categorized as SC, MC, IC, *P_IPB* and *P_UB* respectively.

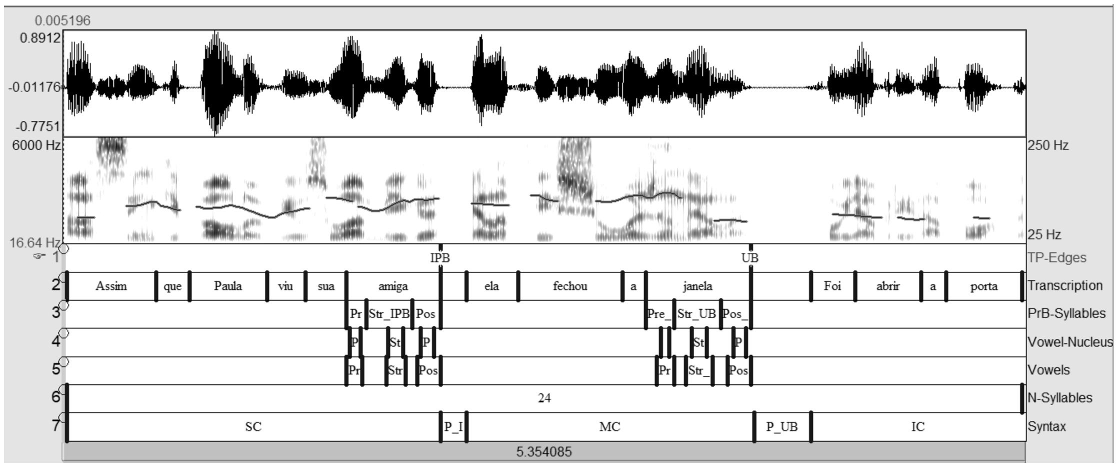


Figure 32: Example TextGrid for Type A showing the annotation with the tires we considered in this study.

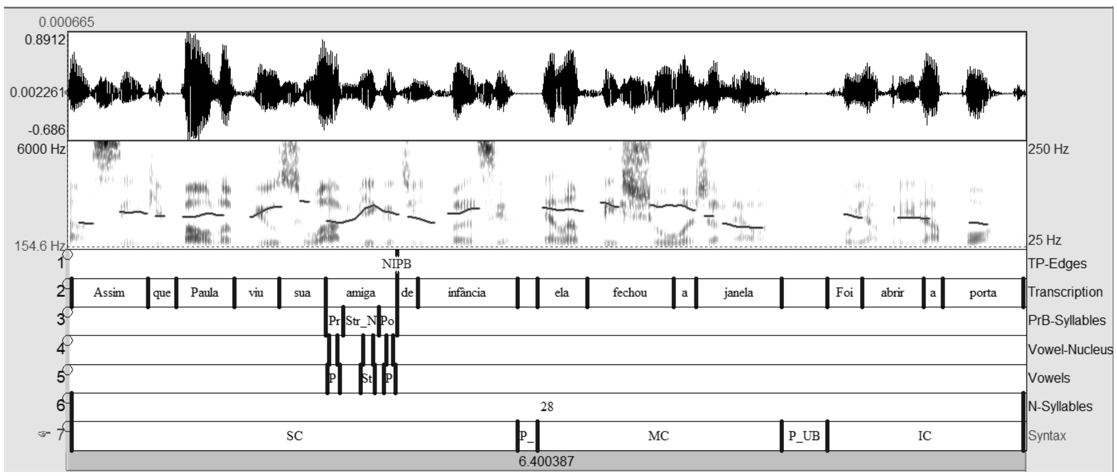


Figure 33: Example TextGrid for Type B showing the annotation with the tires we considered in this study.

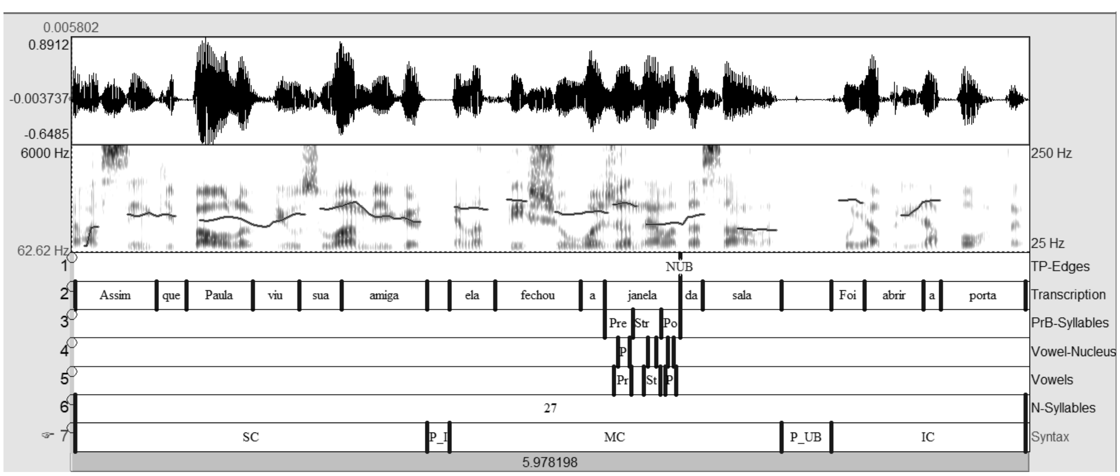


Figure 34: Example TextGrid for Type C showing the annotation with the tires we considered in this study.

A total of 360 stimuli (including Type A, Type B and Type C) was analyzed. We ran a Praat script called “Analyse_tier” (HIRST, 2012). For each interval or point on selected tier the script calculates duration and, depending on the options selected, mean/minimum/maximum pitch (using Hertz/octaves/semitones and 1, 100, 200, 440 or median as reference) and intensity. The results are output to an “Info window” and can be saved as a .txt file which can be read directly by a statistics package like Excel Worksheet.

Acoustic cue measurement was first conducted in the three syllables of the “target words”. The pre-final syllable lengthening was determined by measuring mean duration taken at the vowel of the syllables (in tier 5 of Praat TextGrid). For this measurement, duration values were normalized using a z-score formula. The pitch variation was determined by calculating the mean difference between maximum and minimum fundamental frequency (F0) taken at the vowel nucleus of the syllables (in tier 4 of Praat TextGrid). Mean values of mean F0 and intensity were also measured in the vowel nucleus of these syllables.

Pause was assessed by measuring the duration of “interval of silence” marking *IPB*, *NIPB*, *UB* and *NUB* in the experimental items, when it occurred (in tier 7 of Praat texGrid). Any interval of silence greater than 150 ms was considered a pause, following Kowal et al. (1983).

Comparisons of acoustic analysis data associated with *IPB, NIPB, UB* and *NUB*, were conducted as follows: (i) *IPB vs. NIPB;* (ii) *UB vs. NUB;* (iii) *IPB vs. UB*. We only report statistically significant differences between acoustic cues.

4.3.3. Results of acoustic analysis

As regards pause, the “intervals of silence” *P_IPB* ranged between 34 ms and 150 ms, and *P_UB* ranged between 260 and 388. Thus, *P_UB* was always long enough to be considered a pause; that was not the case for *P_IPB*. Notably, *NIPB* and *NUB* were never marked by “interval of silence” or pause (in 100% of experimental items). The comparison revealed that *P_UB* was longer in duration [*P_UB*, M= 305 ms (SE= 0.55); *P_IPB*, M= 113 ms (SE= 1.21); t (718)= -143.8, p< 0.001]. Figure 35 shows a graphic representation of the difference between mean durations of *P_IPB* and *P_UB*.

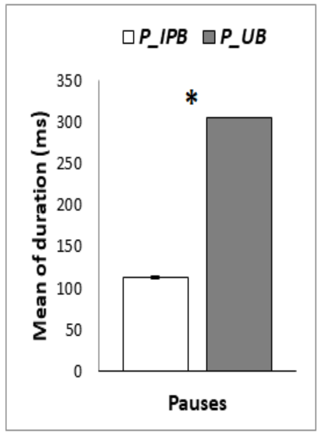


Figure 35: Mean duration of *P_IPB* and *P_UB* in milliseconds (ms). The asterisk (*) indicates significant differences.

Acoustic analysis data for the three syllables preceding *IPB* and *UB* were compared with those preceding *NIPB* and *UB*, respectively. We also compared the results from acoustic analysis of the three syllables preceding *IPB* with those preceding *UB*. The data were subjected to two-sample *t*-tests. An overview of the results is presented in Table 1, where only significant differences were reported.

Table 1: Statistical analysis results of comparison of acoustic analysis data associated with *IPB, NIPB, UB* and *NUB*.

	Lengthening (ms)		Pitch variation (Hz)		Mean F0 (Hz)		Mean intensity (dB)	
Syllables	t (df)	Mean (SE)	t (d)	Mean (SE)	t (df)	Mean (SE)	t (df)	Mean (SE)
Pre_IPB *vs.* *Pre_NIPB*					6.7 (237)***	114.8 (23) > 96.9 (1.1)	2.2 (238)*	75.3 (0.3) > 74.3 (0.3)
Str_IPB *vs.* *Str_NIPB*	10.4 (238)***	1.1 (0.05) > 0.2 (0.05)					3.5 (238)***	75.9 (0.2) > 74.6 (0.2)
Pos_IPB *vs.* *Pos_NIPB*	6 (235)***	-0.3 (0.3) > -0.6 (0.03)	2.3 (229)**	8 (0.49) > 6.4 (0.4)				
Pre_UB *vs.* *Pre_NUB*			3 (232)**	11.9 (0.9) < 16 (1)	-2.5 (232)**	122.8 (2.2) > 115.5 (1.6)		
Str_UB *vs.* *Str_NUB*	-10.2 (236)***	0.9 (0.05) > 0.1 (0.05)	4.3 (236)***	10.3 (0.7) < 15.9 (1)	16.6 (236)***	84.7 (0.7) < 116 (1.7)	5.9 (237)***	72.9 (0.2) < 75.1 (0.2)
Pos_UB *vs.* *Pos_NUB*	-3.6 (235)***	-0.3 (0.03) > -0.5 (0.03)	3 (232)**	5.9 (0.6) < 8.7 (0.7)	18.9 (202)***	78.1 (0.7) < 127.6 (2.1)	18.5 (238)***	62.8 (0.4) < 73.5 (0.3)
Pre_IPB *vs.* *Pre_UB*			2.3 (239)**	8.7 (0.6) < 11.3 (0.9)	-2.4 (239)**	114.8 (2.3) < 122.8 (2.2)		
Str_IPB *vs.* *Str_UB*	2.5 (238)**	1.1 (0.05) > 0.9 (0.05)			12.1 (236)***	100.4 (0.9) > 84.7 (0.7)	8.1 (239)***	75.9 (0.2) > 72.9 (0.2)
Pos_IPB *vs.* *Pos_UB*			2.5 (202)**	8 (0.4) > 5.9 (0.6)	9.1 (202)***	104.1 (2.3) > 78.1 (0.7)	14.6 (239)***	71.3 (3.5) > 62.8 (0.4)

(*) stands for p≤ 0.05; (**), for p≤ 0.01; (***), for p≤ 0.001; (>), for greater than; (<), for smaller than.

Acoustic cues associated with *IPB, NIPB, UB* and *NUB* are represented in Figure 36. The stressed syllables were compared as follows: *Str_IPB vs. Str_NIPB*; *Str_UB vs. Str_NUB; Str_IPB vs. Str_UB.*

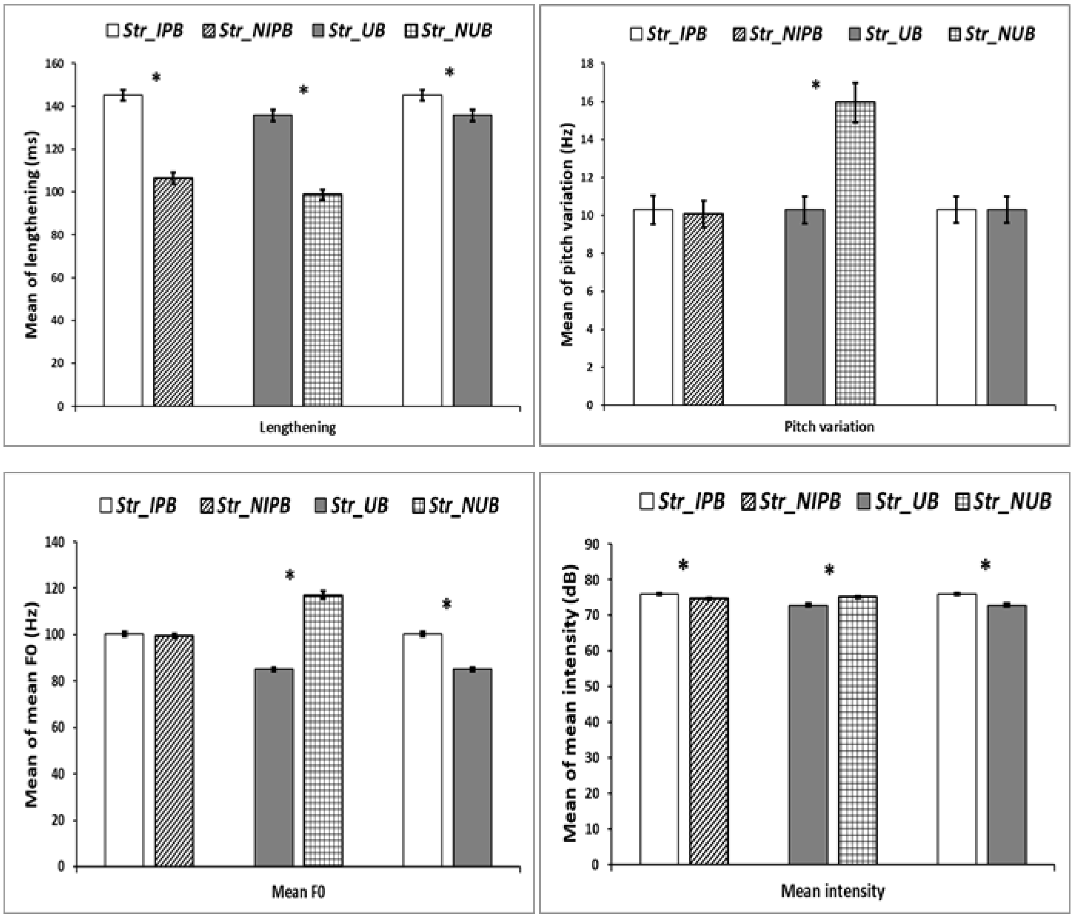


Figure 36: Acoustic cues associated with *IPB, NIPB, UB* and *NUB,* where stressed syllables are compared as follows: *Str_IPB vs. Str_NIPB*; *Str_UB vs. Str_NUB* and *Str_IPB vs. Str_UB.* The Asterisks (*) indicate significant differences.

In sum, with regard to the major prosodic cues marking prosodic boundaries, the results clearly indicate the following: *IPB*, as compared to *NIPB*, is characterized by a longer final stressed vowel (vowel lengthening) and by a higher intensity associated with the final stressed syllable; *UB*, as compared to *NUB*, is characterized by a longer final stressed vowel (vowel lengthening) and by a lower pitch variation, mean F0 and mean intensity, associated with the final stressed syllable. Regarding *UB* and *NUB*, the result may be attributable to the more salient falling tone marking *UB* as compared to *NUB,* which is marked by a "continuative tone". *UB* is also characterized by the obligatory presence of a pause, as compared to *NUB*, *IPB* and *NIPB*.

Principally, *IPB* as compared to *UB*, is marked by longer pre-final syllable lengthening, higher mean F0 and higher mean intensity in pre-boundary stressed syllables. *IPB* was also marked by a shorter "interval of silence" not considered a pause, as compared to *UB* which was marked by a pause. An overview of the comparison of two main acoustic cues

(Final lengthening and Mean F0) characterizing the stressed syllables of the “target words” is presented in Table 2.

Table 2: Comparison of two main prosodic cues characterizing the stressed syllables of “target words”.

		IPB	NIPB	UB	NUB
Final lengthening	IPB		>	>	
	NIPB				
	UB				>
	NUB				
Mean F0	IPB		=	>	
	NIPB				
	UB				<
	NUB				

(>), for greater than; (<), for smaller than; (=), for equal.

These results clearly indicate, in consonance with the literature (MORAES, 1995; WICHMANN, 2000; OLIVEIRA, 2000; FROTA & VIGÁRIO, 2000; TENANI, 2002; FERNANDES, 2007; SERRA, 2009; SERRA & FROTA, 2009; CHACON & FRAGA, 2014), that from the perspective of production, prosodic boundaries of different hierarchy are characterized differently. They also demonstrate that many of these differences appear before the onset of the boundary itself.

4.4. Participants

Thirty volunteers participated in the ERP experiment (15 males; mean age: 24.31 years; SD: 3.1). All the participants were native speakers of Brazilian Portuguese and students at the Federal University of Alagoas, in Brazil. They were right-handed as assessed by a Brazilian Portuguese version of the Edinburgh Handedness Inventory (OLDFIELD, 1971), with no hearing disorder or previous history of neurological or psychiatric disorders based on self-declaration.

4.5. EEG experimental paradigm

For EEG experiment, we used a Geodesic EEG System 400 (*Electrical Geodesics, Inc*), with a *HydroCel Sensor Net* of 256 channels (see Figure 37 for sensor net map), a Net Amps 400 series of EEG amplifiers and a complete Net Station suite of software for EEG acquisition and analysis. The system also includes E-Prime software[3] for experiment design and stimuli presentation.

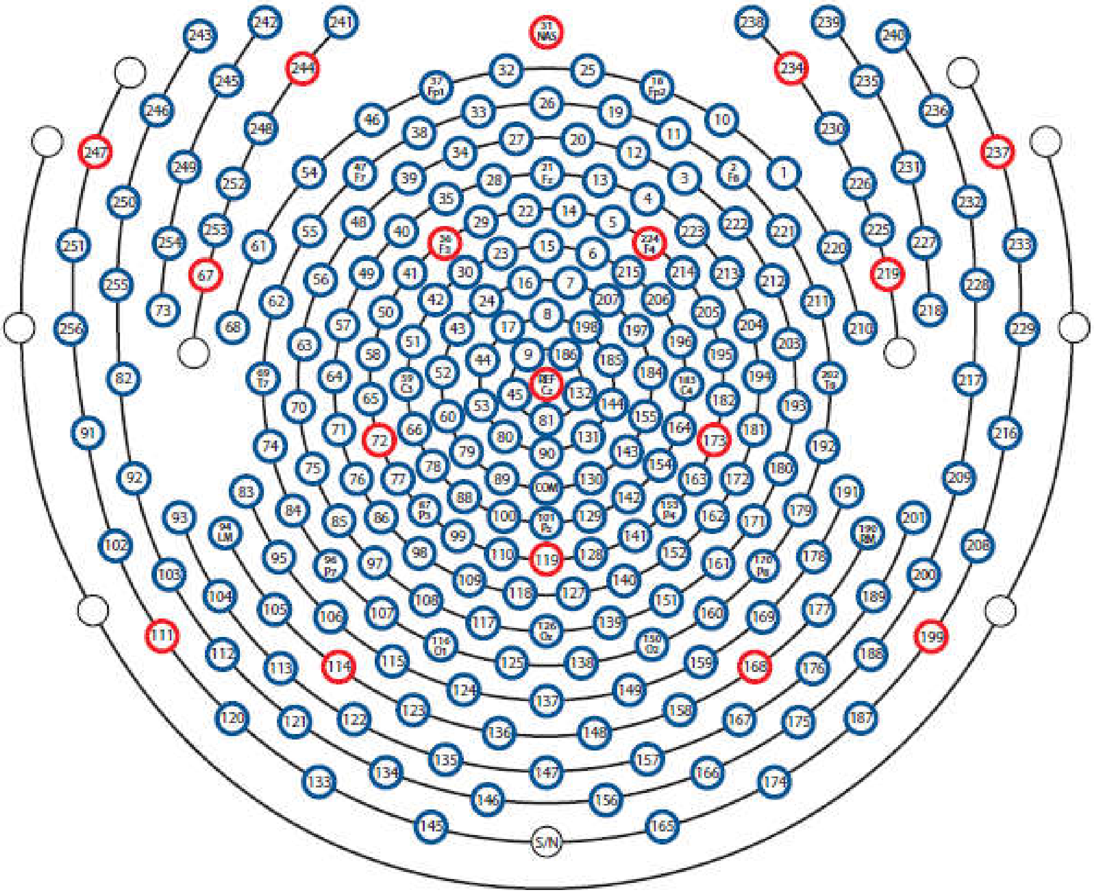


Figure 37: Map for *hydroCel Sensor Net* of 256 channels.
Source: *Electrical Geodesics, Inc*[4]

As regards the stimuli, we opted to control for pause duration (if it occurred). Thus, the duration for all the pauses following *UB* was set to 300 ms. This was done digitally directly in the sound file, without compromising the naturalness of the items. The duration of 300 ms was chosen based on the mean duration of all the pauses found at *UB*. Since pause does not play an important role in the processing of prosodic boundaries (STEINHAUER et

[3] E-Prime Software is a psychological tool that can be used to design complete experiments without programming. Available at: https://pstnet.com/products/e-prime/. Accessed on 07/06/2018.
[4] Available at:< https://www.egi.com/knowledge-center. Accessed on 07/06/2018>. Accessed on 07/06/2018.

al., 1999) and since variation in pause duration might interfere with the description of the CPS for the present study, in terms of onset latency and amplitude, we decided to control for that.

Three lists of stimuli were used. Each list contained only one version of the statements that served as stimuli. In E-Prime software, a pseudorandom order of experimental materials and fillers was designed with the constraint that the same Type of stimulus was not presented twice in a row. The participants were divided into three groups of ten individuals. Each group had access to one list. Each list contained 240 stimuli divided into 6 experimental blocks of 40 stimuli of no more than 5 minutes with rest pauses between blocks.

In line with the methodological approach suggested in a previous study (BÖGELS et al., 2011), and considering the results of the acoustic analysis of the experimental material of the present study, we opted to time-lock our ERP response to the onset of the pre-boundary stressed syllables. To that aim, we set markers, which are four letter/digit/symbol signs (called event-trigger codes), indicating “critical events” during the presentation of each stimulus in E-Prime software. The Software has an extension for Net Station. In its basic features it sends event-trigger codes, marking the onset and offset of a stimulus, to Net Station during EEG signals recording. The Figure 38 illustrates the experiment´s structure in E-Prime, with the different stages for stimuli presentation.

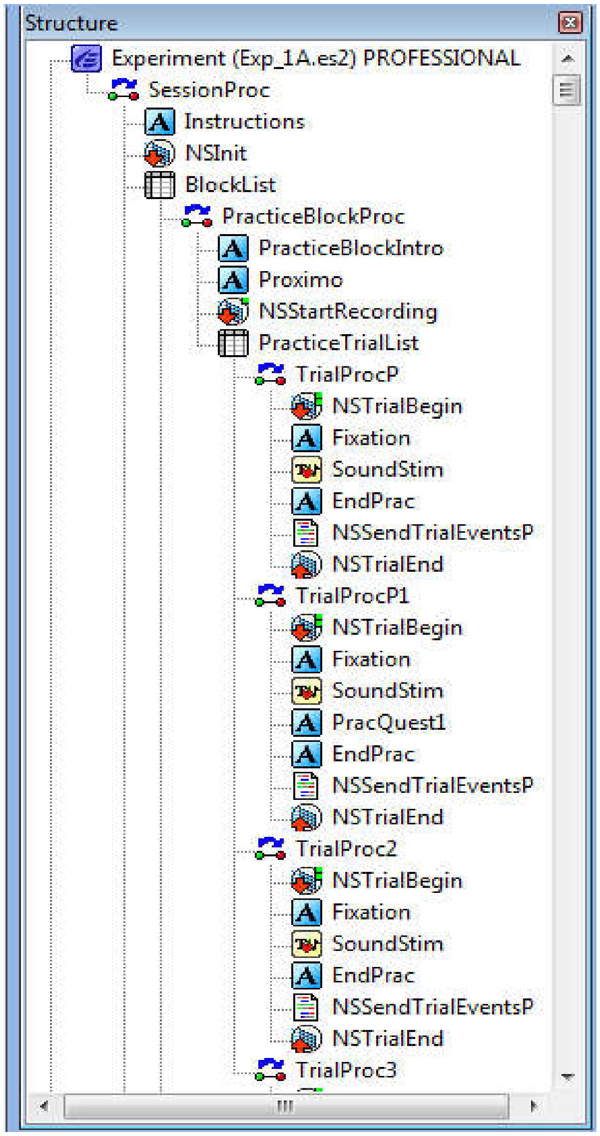


Figure 38: The structure of the experiment in E-Prime

In Figure 38, we illustrate “critical events” during the presentation of each stimulus as follows: ***Fixation,*** for the fixation point (+), on the stimulus-presentation monitor, preceding the stimulus, indicated with “***fix+***”; ***SoundStim,*** for the onset of the stimulus, indicated with “***stm1***”; ***EndTrial***, for the offset of the stimulus, indicated with “***stm-***”.

In this study, since we investigate at least one more event (that is, onset of *IPB, NIPB, UB* or *NUB*) within each stimulus asides its onset and offset, we had to write an E-Prime Script that provided Net Station with temporal information associated with these events within each stimulus. The E-Prime Script is set at ***NSSendTrialEvents*** stage in the experiment´s structure (see Figure 38 above) and read the information shown in Figure 39 below. With the Script, we marked, in Type A, the onset of *IPB* with ***stm2*** and that of *UB*, with ***stm3***. In Type B and Type C, the onset of *NIPB* and *NUB* were marked with ***stm4*** and ***stim7*** respectively. Notably, from our acoustic analysis we had accessed to temporal information associated with the onsets of these "target events". As can be seen in the E-Prime Script (see Figure 39) and illustrated in Figure 40, ***stm3*** = ***stm2*** + 1576 ms.

```
NetStation_HandlePreRelease

' Send response event using data collected from specified object
NetStation_SendRespEvent c, SoundStim

' Send a trial event for each presentation in the trial
NetStation_SendTrialEvent c, Fixation
NetStation_SendTrialEvent c, SoundStim
SoundStim.onsetTime = SoundStim.onsetTime + 1296
SoundStim.tag = "stm2"

NetStation_SendTrialEvent c, SoundStim
SoundStim.onsetTime = SoundStim.onsetTime + 1576
SoundStim.tag = "stm3"
NetStation_SendTrialEvent c, SoundStim
SoundStim.tag = "stm1"

NetStation_SendTrialEvent c, EndTrial

' Send the trial specific event
NetStation_SendTRSPEvent c, SoundStim
```

Figure 39: E-Prime Script for "critical events" within Type A (stimulus 1A).

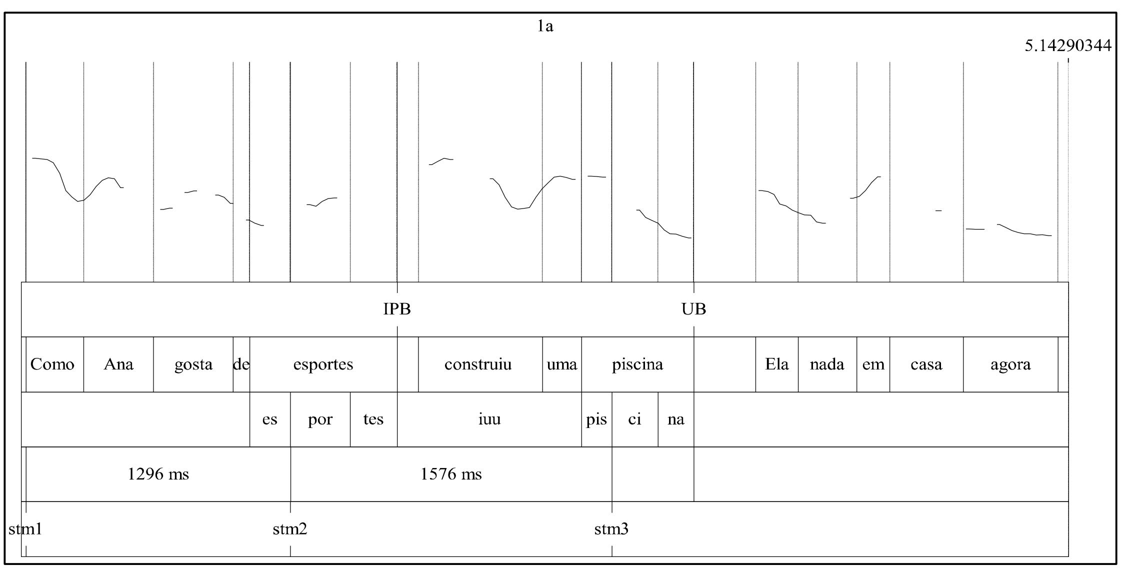


Figure 40: Praat picture for Type A (stimulus 1A) showing the event-trigger codes *stm1, stm2* and *stm3* marking onsets of the stimulus, the *IPB* and the *UB* respectively.

For EEG signals recording, the participants were seated in a comfortable chair placed 1 meter away from the stimulus-presentation monitor (see Figure 41). We used E-Prime software, from the experimenter´s computer (see Figure 41), to present the stimuli to the participants via headphones (*Sennheiser* hd280 pro). The sound loudness of the experimenter´s computer was controlled and set at 22 % for all the participants. We confirmed each participant was comfortable with the sound loudness by playing a sound file before starting the experiment).

In the beginning of the experiment, a written instruction informed the participants about the experiment. They were asked to listen carefully to the sentences. The experiment started with a practice session of 10 sentences. A trial always started with a written prompt *"próximo estímulo"* ("Next trial", in English) of 100 milliseconds, followed by a fixation point (+) on the stimulus-presentation monitor. The sentence started 200 milliseconds after the fixation. Participants were asked to look at the fixation point to avoid eye-movements and blinks until the offset of a sentence. The stimuli were randomly followed by a written prompt (a word). In the task, the participants were asked to indicate via a key press (on the subject response pad, see Figure 41) if the prompted word was present or absent from the immediately preceding stimulus (in 5% of stimuli for each participant). This task was given to ensure that the participants were paying attention while listening to the sentences.

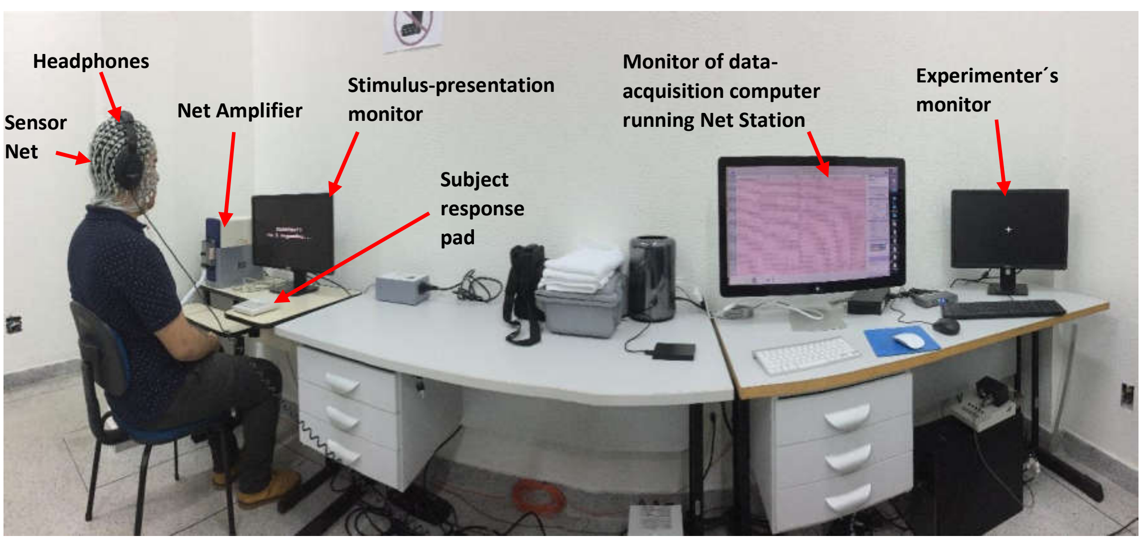


Figure 41: Experiment-control set up.

4.6. EEG recording procedure

The experiment was conducted in the Psycholinguistics Laboratory at the Federal University of Alagoas *(Laboratório de Pesquisa da Linguagem, do Cérebro e do*

Comportamento Humano – Lapelc[2]), in Brazil. For each participant, we made sure that sensors (or electrodes) of the EEG System were in good contact with the scalp, that the EEG signal did not contain electrical noise and that electrodes were adjusted till their impedances were kept below 5kΩ. EEG data was recorded with a high-pass filter at 0.1 Hz and sampling rate set at 1000 Hz. The online recording reference for all sensors in the EEG data was Cz. The Net Station acquisition software recorded EEG data continuously along with the event-trigger codes sent by E-Prime software, as illustrated in Figure 42. After the recording, the EEG datasets were pre-processed offline using Net Station acquisition software tools.

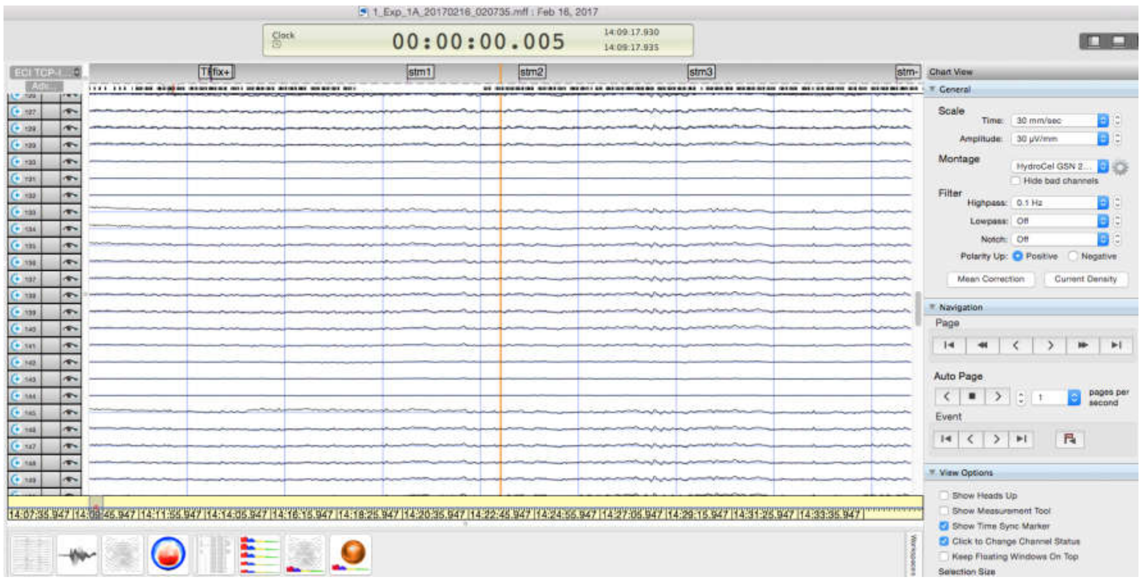


Figure 42: Net Station acquisition software tools showing EEG data continuously recorded with event-trigger codes (***fix+****, **stm1**, **stim2**, **stm3** and **stm-***).

4.7. Processing the EEG

For offline EEG analysis, we first pre-processed the raw EEG datasets in Net Station acquisition software tools. The datasets were low-pass filtered at 30 Hz, re-referenced to the average reference and divided into sections (epochs) that started 300 ms prior to the onset of the stressed syllable in the "target words" (marked with event-trigger codes ***stm2, stim3, stm4*** and ***stm7,*** indicating the onsets for ***IPB, UB, NIPB*** and ***NUB*** respectively) and ended 2200 ms after that onset. The pre-processed EEG datasets were then exported as *Netstation binary simple file* and saved into *raw* format. Figure 43 shows epochs of the EEG data in Net Station acquisition software tools.

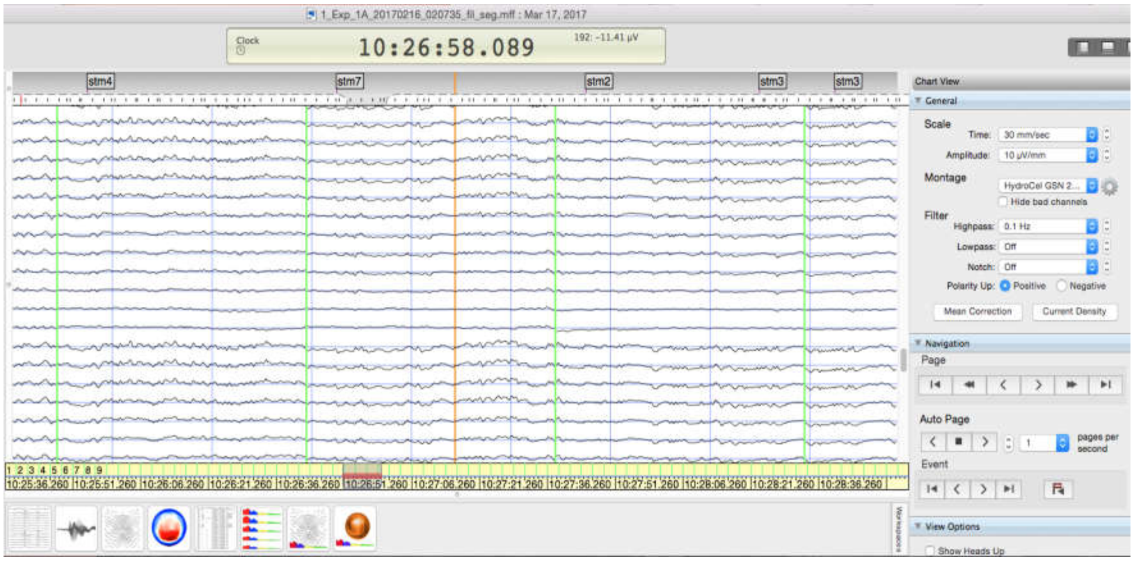


Figure 43: Net Station acquisition software tools showing epochs of the EEG data, with time-window -300 ms to 2200 ms (marked with the vertical green line).

After, we run EEGLAB (DELORME & MAKEIG, 2004) in MATLAB and imported the epoched EEG datasets. Then, we loaded the Channel Location file for the 256-channels *HydroCel Geodesic Sensor Net* (see Anex V). Figure 44 shows epochs of the EEG data in the *eegplot() scrolling data window***.**

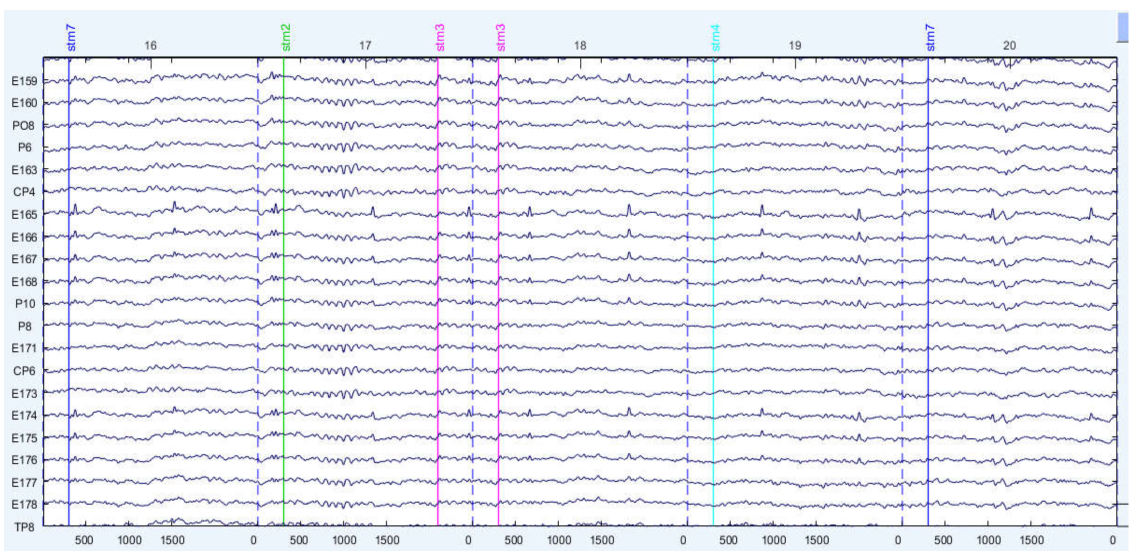


Figure 44: *eegplot() scrolling data window*, in EEGLAB, showing epochs of the EEG data, with time-window -300 ms to 2200 ms (marked with the vertical dotted blue line).

In ERPLAB (LOPEZ-CALDERON & LUCK, 2014), we used the "Utilities" function to convert the epoched EEG datasets into continuous ones. Figure 45 illustrates the continuous EEG datasets. This conversion is required in order to proceed with analysis in ERPLAB.

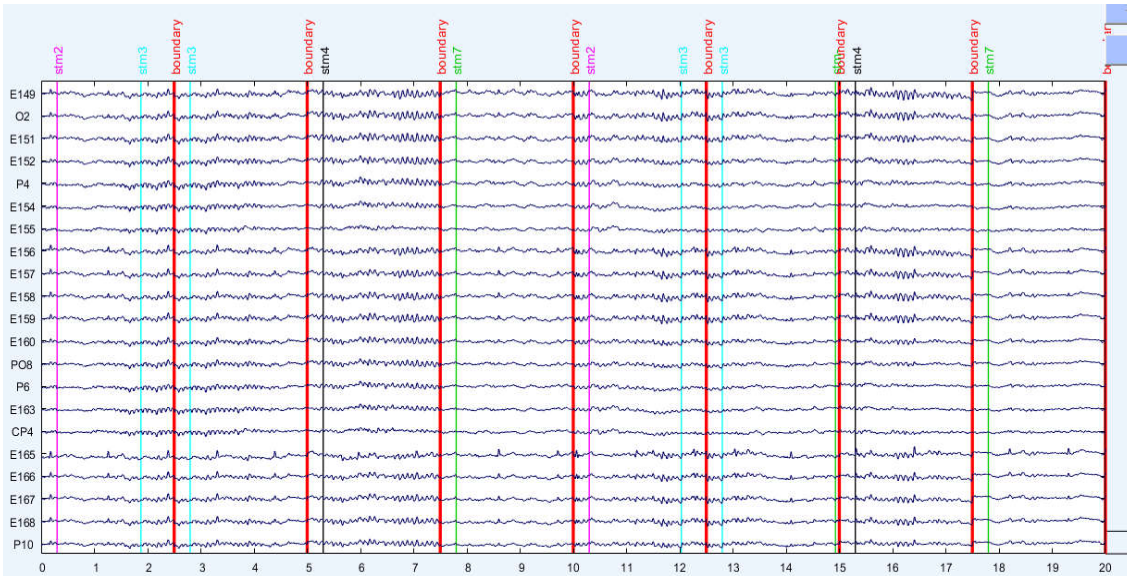


Figure 45: *eegplot() scrolling data window*, in EEGLAB, showing continuous EEG data.

We then continued in ERPLAB. After the *EventList* and *BINLISTER* analyses (where we assigned *bin* (B) as follows: B1, for ***stm2***; B2, ***stim3***; B3, ***stm4*;** and B4 for ***stm7***) we did the *Epoching* analysis, dividing the continuous EEG datasets into epochs that started, this time, 200 ms prior to the onset of the stressed syllable in the "target words" and ended 2000 ms after that onset. Figure 46 shows epochs of the EEG data in the *eegplot() scrolling data window***.**

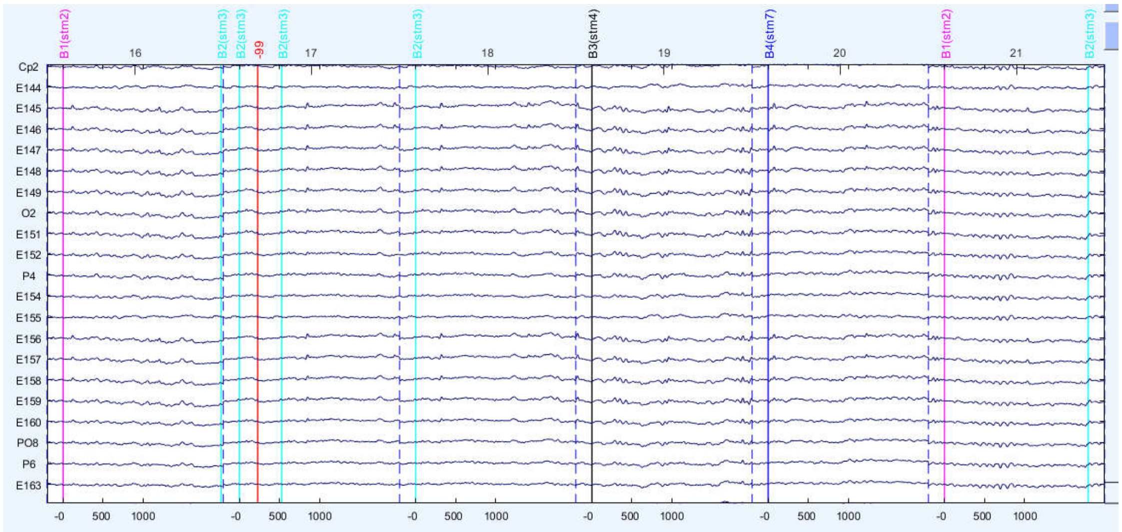
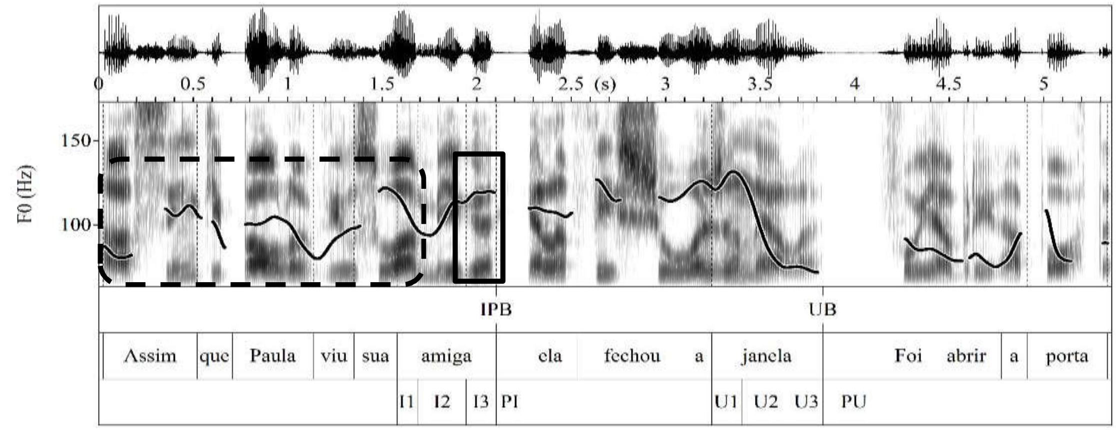


Figure 46: *eegplot() scrolling data window*, in EEGLAB, showing epochs of the EEG data, with time-window -200 ms to 2000 ms (marked with the vertical dotted blue line).

Then, epochs of EEG that contained large muscle artefacts were removed from the data by visual inspection. Ocular artefact correction was performed using independent component analysis (ICA) as implemented in EEGLAB (‘eeg_runica’ function). Independent components with known features of eye blinks (based on activity power spectrum, scalp topography, and activity over trials) were identified visually for each participant. The contributions of these components were then removed from the epoched EEG data. Artefacts were detected and removed automatically by using a moving window peak to peak procedure, with a 200 ms moving window, a 100 ms window step, and a 100 µV voltage threshold.

Epochs were averaged to produce an ERP for each prosodic boundary condition. Each participant had at least 70% accepted trials per condition [*IPB*, M= 94.25 (SD= 7.46); *NIPB*, M= 93.08 (SD= 8.7); *UB*, M= 93.85 (SD= 5.69); *NUB*, M= 94.08 (SD= 8.1)]. Individual ERP waves were averaged to get grand averaged ERPs for each condition. Since the pairs of conditions – *IPB vs. NIPB* and *UB vs. NUB* – contained the same lexical and prosodic information up to the onset of the stressed syllables of the “target words” (see Figure 47 for *IPB vs. NIPB* and Figure 48 for *UB vs. NUB*), the comparisons of grand averaged ERPs in our time-windows [0−2000 ms] would reflect the processing of prosodic cues marking the *IPB* and *UB*. For statistical analysis and topographic representation of ERP waveforms, we considered 19 electrodes, in line with the international 10-20 system, as used in previous auditory ERP studies (Peter, Mcarthur & Crain, 2014). The electrodes were organized as follows: Midline Electrodes: Cz, Pz and Fz; Lateral electrodes were grouped into six regions of interest (ROIs): right anterior (F4, F8, FT8), right posterior (P4, P8, CP4, TP8), left anterior (F3, F7, FT7), left posterior (P3, P7, CP3, TP7), left central (FC3) and right central (FC4).

Type A



Type B

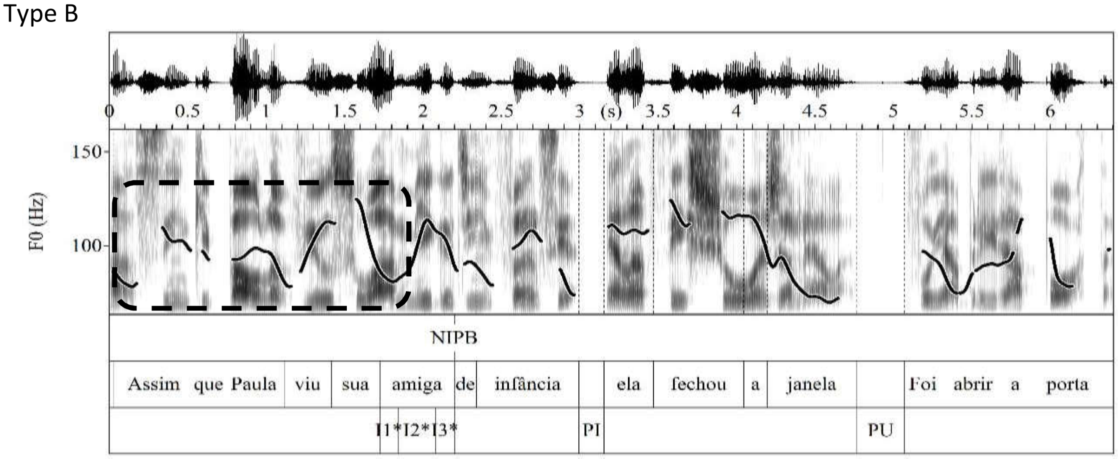
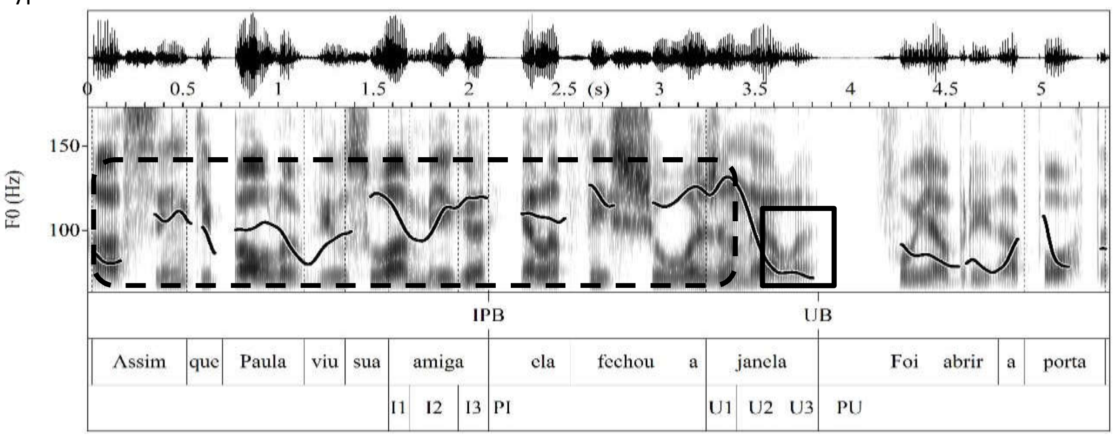


Figure 47: Example of pair of conditions for intonational phrase. *IPB* in type A, *NIPB* in type B. In type A, the dotted black rectangle indicates the intonational contour of IP up to the onset of pre-boundary stressed syllable and in type B, the contour of same portion of IP with no prosodic boundary. The solid black rectangle in type A indicates boundary tones of *IPB*. I1, I2 and I3 stand for *Pre_IPB, Str_IPB* and *Pos_IPB* respectively. U1, U2 and U3 stand for *Pre_UB, Str_UB* and *Pos_UB* respectively. I1*, I2* and I3* stand for *Pre_NIPB, Str_NIPB* and *Pos_NIPB* respectively. PI and PU stand for *P_IPB* and *P_UB* respectively.

Type A



Type C

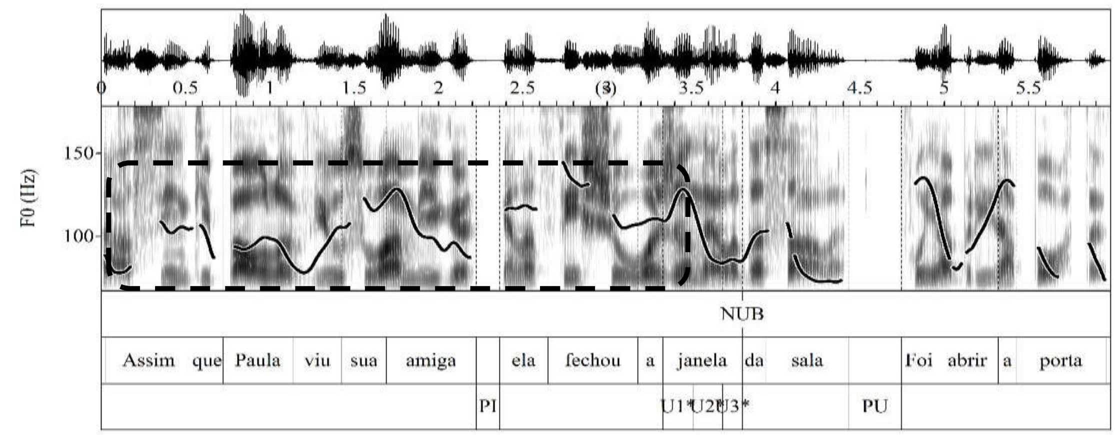


Figure 48: Example of pair of conditions for phonological utterance. *UB* in type A, *NUB* in type C. In type A, the dotted black rectangle indicates the intonational contour of U up to the onset of pre-boundary stressed syllable and in type C, the contour of same portion of U with no prosodic boundary. The solid black rectangle in type A indicates boundary tones of *UB*. I1, I2 and I3 stand for *Pre_IPB, Str_IPB* and *Pos_IPB* respectively. U1, U2 and U3 stand for *Pre_UB, Str_UB* and *Pos_UB* respectively. U1*, U2* and U3* stand for *Pre_NUB, Str_NUB* and *Pos_NUB* respectively. PI and PU stand for *P_IPB* and *P_UB* respectively.

5. RESULTS

5.1. Behavioral Results

5.1.1. Descriptive results

The results for all participants were included in the analysis. The grand averaged ERP waveforms to the pairs of conditions adjusted to a pre-stimulus baseline of [-200 ms] at the 19 electrodes considered for statistical analyses and the representative Cz electrode are illustrated in Figure 49 and Figure 50 for *IPB vs. NIPB,* and in Figure 51 and Figure 52 for *UB vs. NUB* respectively.

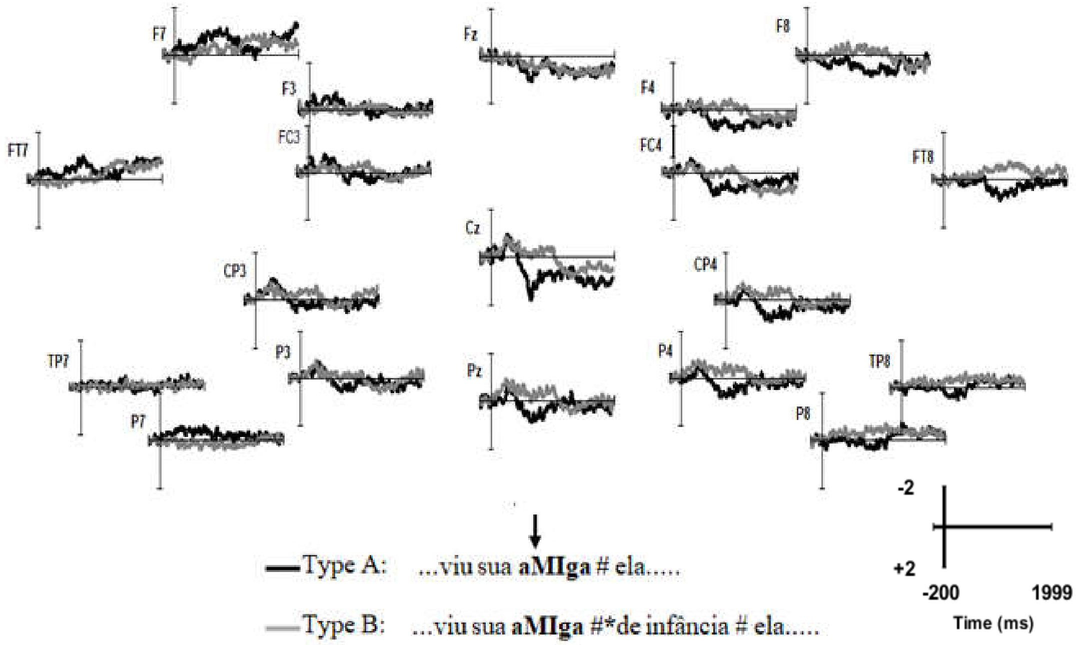


Figure 49: Grand averaged ERPs for IP prosodic boundary and no IP prosodic boundary conditions at the 19 electrodes considered for statistical analysis. Hash (#) stands for *IPB* and hash asterisk (#*) for *NIPB*.

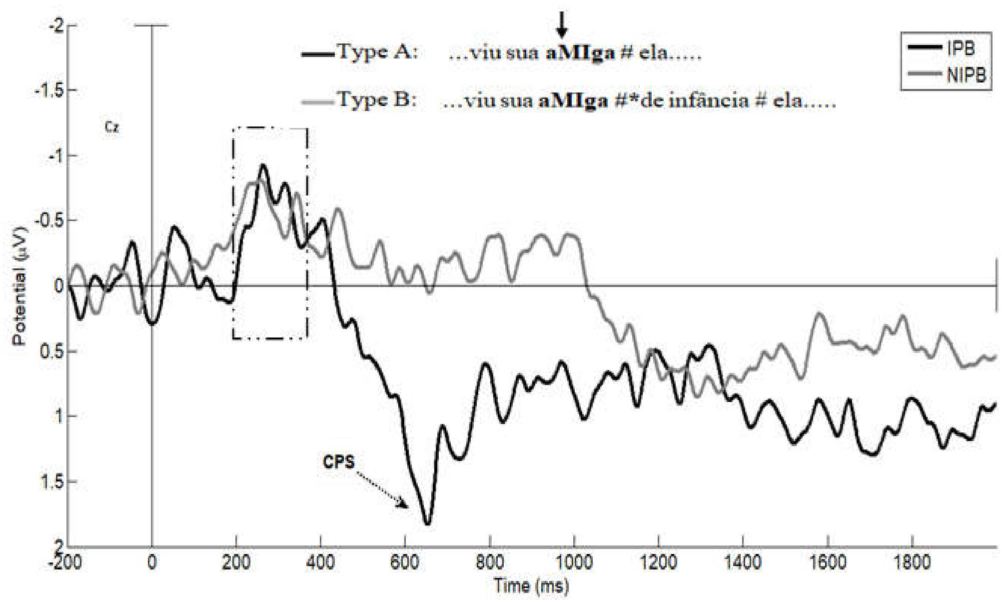


Figure 50: Grand averaged ERPs for IP prosodic boundary and no IP prosodic boundary conditions at Cz electrode. Hash (#) stands for *IPB* and hash asterisk (#*) for *NIPB*. The dotted black rectangle indicates the "Early negativity".

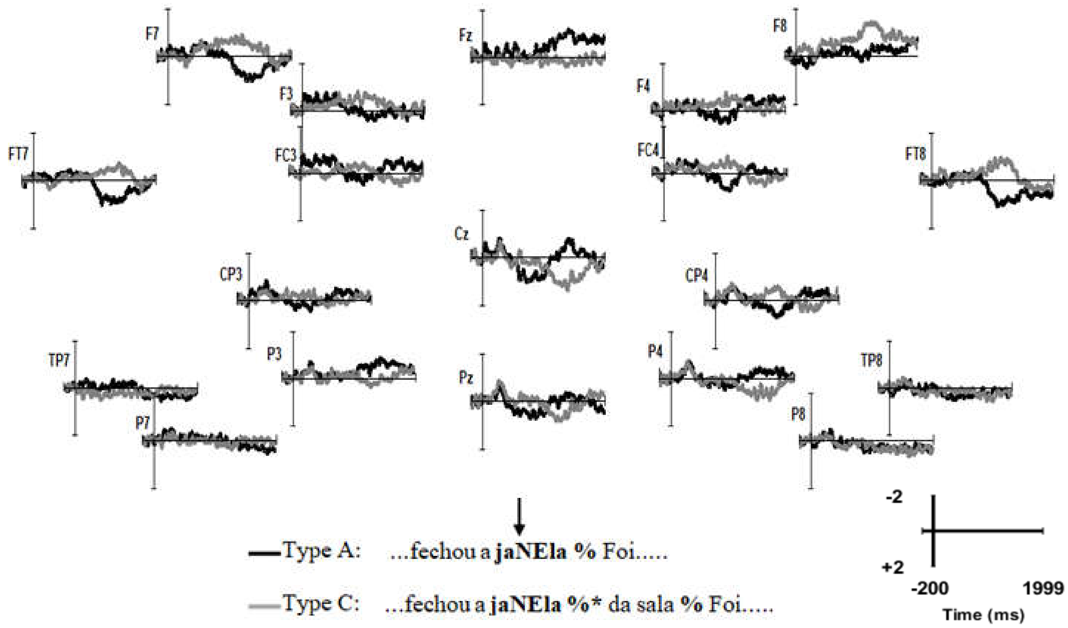


Figure 51: Grand averaged ERPs for U prosodic boundary and no U prosodic boundary conditions at the 19 electrodes considered for statistical analysis. Percentage (%) stands for *UB* and percentage asterisk (%*) for *NUB*.

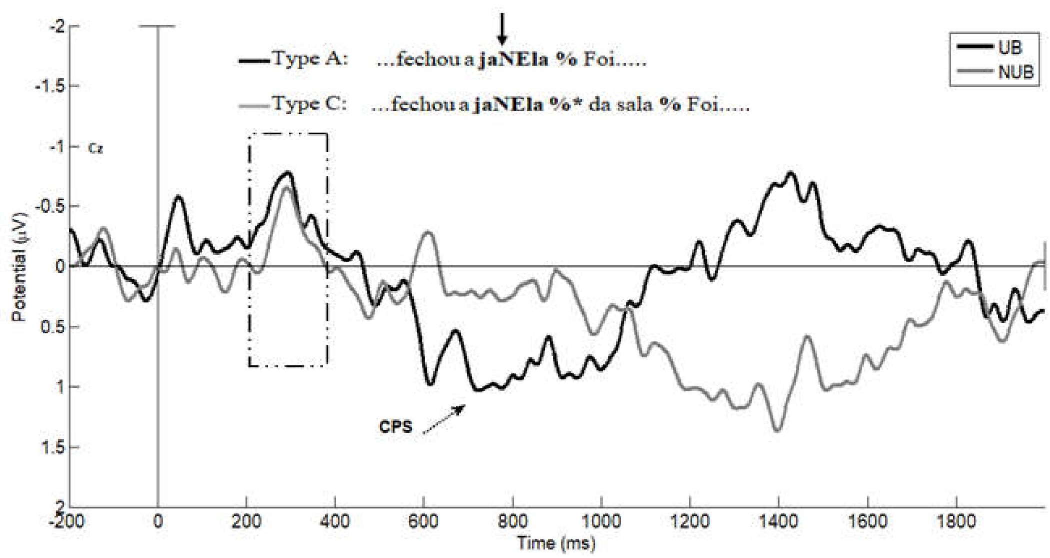


Figure 52: Grand averaged ERPs for U prosodic boundary and no U prosodic boundary conditions at Cz electrode. Percentage (%) stands for *UB* and percentage asterisk (%*) for *NUB.* The dotted black rectangle indicates the "Early negativity".

At the representative Cz electrode in Figure 50 and Figure 52, at the illustrative statements, the solid arrow indicates the time-locking point to measure the ERPs and the stressed syllables of "target words", which are in uppercase. For all conditions, we observed a small negative peak indicated with a dotted black rectangle, which reaches its peak amplitude at about 250 ms after the onset of the stressed syllable of the "target words". Following previous findings (PANNEKAMP et al., 2005; KERKHOFS et al., 2008; BÖGELS et al., 2010; PAUKER et al., 2011), we considered this negativity to be the early more left-lateralized (PANNEKAMP et al., 2005; KERKHOFS et al., 2008; BÖGELS et al., 2010) reversed effect preceding the CPS effect. It has been hypothesized that this “early negativity” is associated with processing of the early cues of a prosodic boundary, like the boundary tone (pre-final syllable lengthening and pitch rise). The fact that this negativity was also observed for *NIPB* and *NUB* suggests that, due to linguistic knowledge (*i.e.*, syntax, semantic), listeners predicted the occurrence of prosodic boundaries which did not ultimately occur. Since this negativity effect is timelocked to the stressed syllable of the “target word”, we also suggest that it is likely reflective of the lexical processing, as it is captured at Cz.

Still at the Cz electrode, after the initial negative peak, we observed a broad positive deflection, indicated by the dotted arrows in Figure 50 and Figure 52, for *IPB* (from ~500 to 1200 ms) and *UB* conditions (from ~600 to 1200 ms). We assumed this is the CPS component of ERPs evoked in response to the processing of prosodic boundaries. As may be seen for *NIPB* and *NUB*, no such broad positive deflection is present in the time window from ~500 to 1200 ms and ~600 to 1200 ms respectively.

In line with previous studies (MÄNNEL & FRIEDERICI, 2009, 2011; PETER et al., 2014) we argued that if a positivity is seen at the prosodic boundaries, this could reflect (1) a genuine CPS response to the prosodic boundary, (2) a N1-P2 response to the onset of the first word following a silent pause, or (3) a combination of both. In order to disentangle the CPS and N1-P2 responses, we performed a second analysis at *UB* where a pause occurred.

5.1.2. Method for second EEG analysis

In EEGLAB, using the “Edit / Event values” function, we set new event-trigger codes in our converted continuous EEG datasets. The following event-trigger codes were set: ***Stm8,*** at onset of the word immediately following *UB* (*PostUB_onset*) in Type A; ***stm9,*** at onset of the word immediately following the “target word” (*NPostUB_onset*) in Type C. Figure 53 illustrates the continuous EEG datasets with the added event-trigger codes (***stm8*** and ***stm9***).

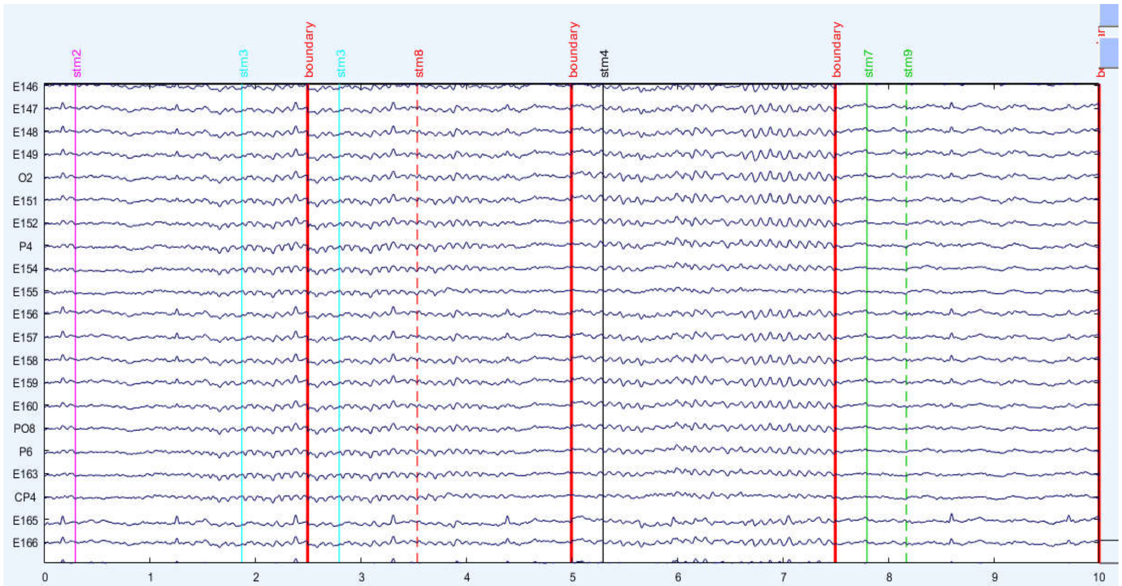


Figure 53: *eegplot() scrolling data window*, in EEGLAB, showing continuous EEG data with the added event-trigger codes (***stm8*** and ***stm9***).

Then, in ERPLAB, after the *EventList* and *BINLISTER* analyses (where we assigned *bin* (B) as follows: B1, for ***stm3***; B2, ***stm8***; B3, **stm7;** and B9, for ***stm4***), we did the *Epoching* analysis, dividing the continuous EEG datasets into epochs that started 250 ms prior to *PostUB_onset* and ended 250 ms after that onset in Type A. Similar time intervals were selected considering *NPostUB_onset* in Type C. This time window allowed us, in Type A, to differentiate the ERP effects that started prior to the onset of the post-boundary word (-250 to 0 ms), where the acoustic cues marking *UB* are available, from the ERP effects that started after the same onset (0 to 250 ms) where the N1-P2 response to the post-boundary words onset overlapped with the ERP response to *UB* (if any). Figure 54 illustrates epochs of the EEG data in the *eegplot() scrolling data window***.**

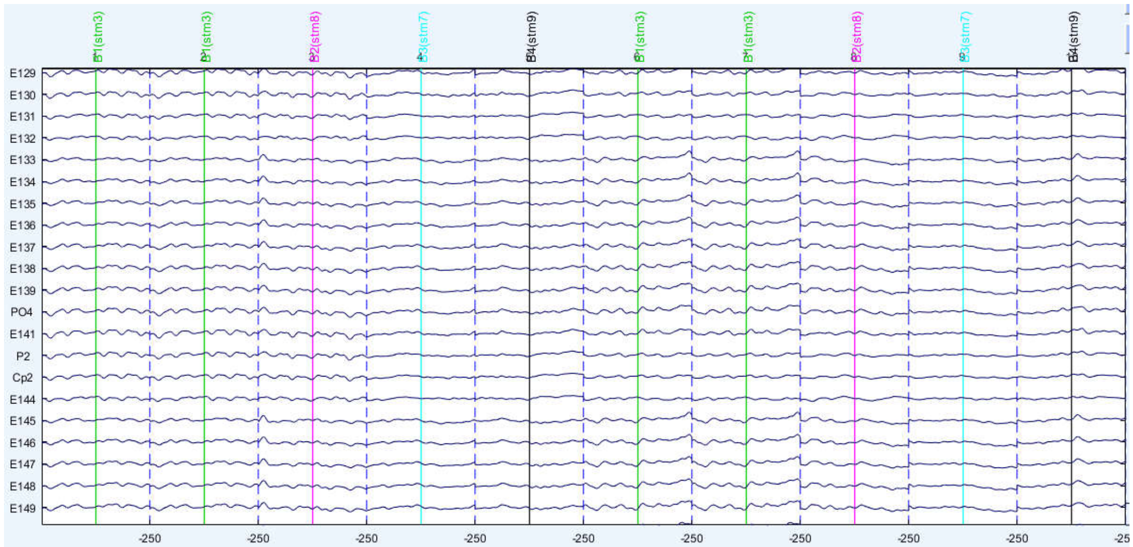


Figure 54: *eegplot() scrolling data window*, in EEGLAB, showing epochs of the EEG data, with time frame -250 ms to 250 ms.

Epochs that contained large muscle artefacts were removed from the data by visual inspection. Ocular artefact correction was performed using independent component analysis (ICA). Artefacts were detected and removed automatically by using a moving window peak to peak procedure, with a 200 ms moving window, a 100 ms window step, and a 100 µV voltage threshold. Epochs were averaged to produce an ERP for each post-prosodic boundary condition. Each participant had at least 85% accepted trials per condition (*PostUB_onset*, M= 93.85, SD= 5.69; *NPostUB_onset*, M= 94.08, SD= 8.1).

5.1.3. Descriptive results for second analysis

The grand averaged ERP waveforms to *PostUB_Onset vs. NPostUB_Onset*, at 19 electrodes are illustrated in Figure 55. Grand averaged ERP responses to *PostUB_Onset vs. NPostUB_Onset* at the representative Cz electrodes are presented in Figure 56.

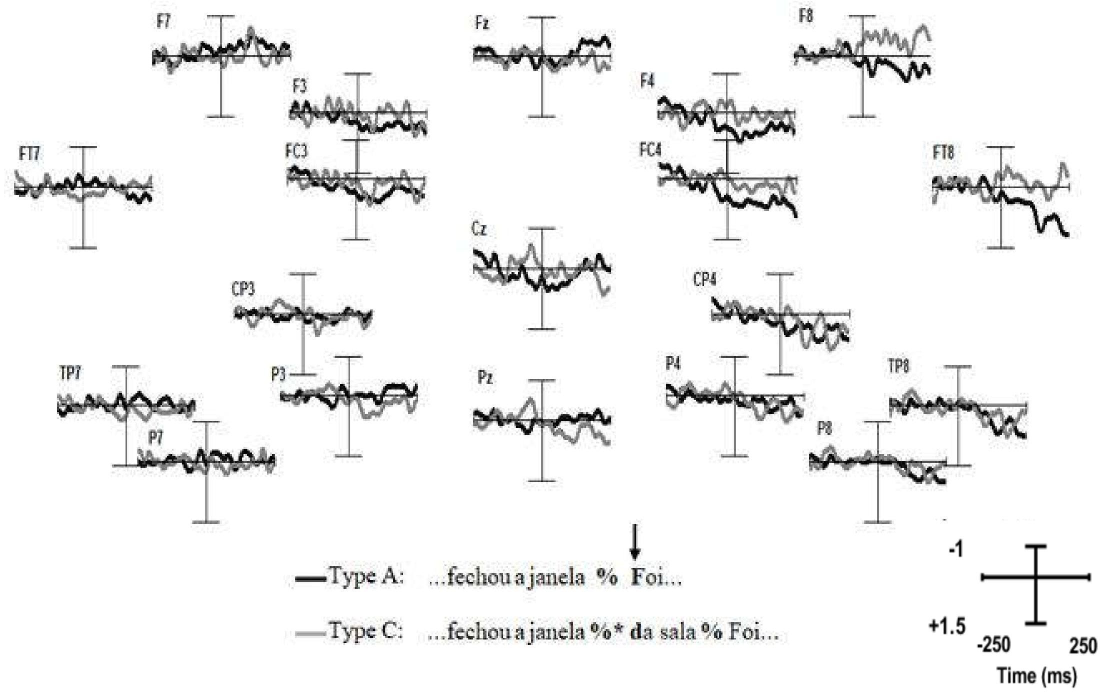


Figure 55: Grand averaged ERPs of *PostUB_Onset vs. NPostUB_*Onset at the 19 electrodes considered for statistical analysis. Percentage (%) stands for *UB* and percentage asterisk (%*) for *NUB.*

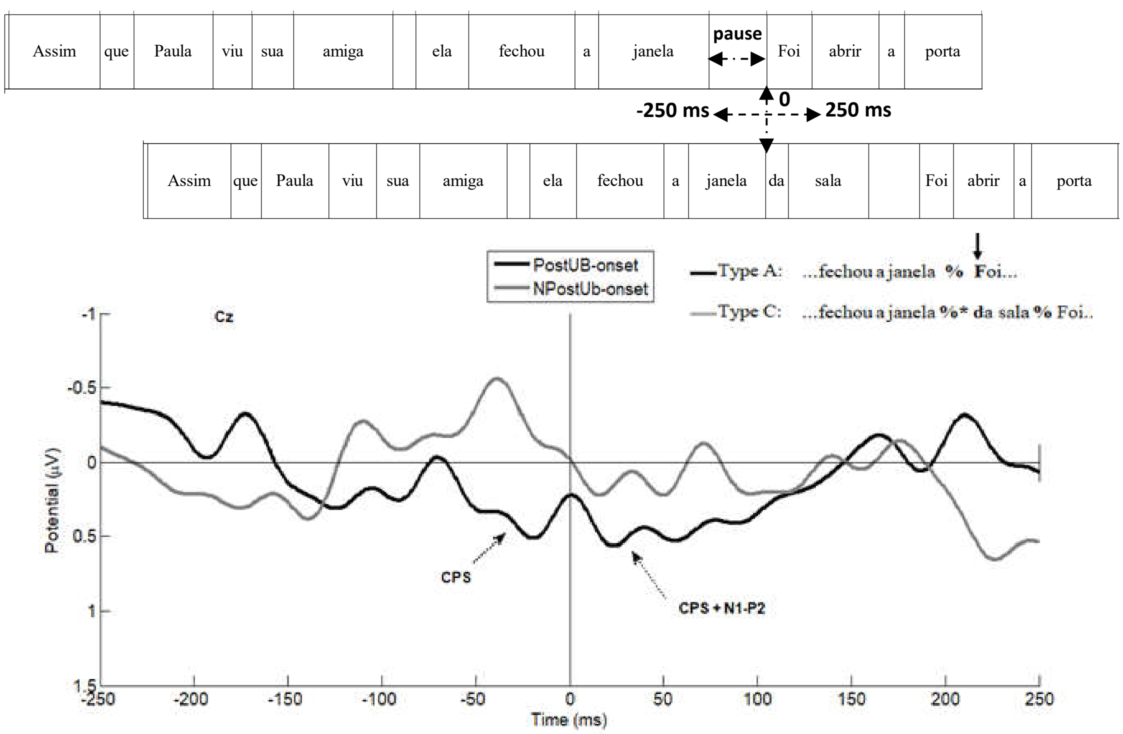


Figure 56: Grand averaged ERPs of *PostUB_Onset vs. NPostUB_Onset* at the representative Cz electrode. Percentage (%) stands for *UB* and percentage asterisk (%*) for *NUB.*

At the Cz electrode, in Figure 56, the solid arrow at the illustrative statement indicates the time-locking point to measure N1-P2 and onsets of words immediately following the “target words” in Type A and Type C, which are in bold font. We observed positive ERP responses in both time-windows ([-250–0 ms] and [0–250 ms]) for *PostUB_onset*. This indicated that the CPS in response to the processing of the U prosodic boundary started before the onset of the word immediately following this boundary, and later merged with the N1-P2 response to that word´s onset (with baseline 0 ms), as indicated by the dotted arrows in Figure 56.

5.2. Statistical analysis

In ERPLAB, using “*ERP Measurement Tool/ Measurement Type/ Mean amplitude between two fixed latencies*” function, we first conducted three separate analyses: “Early negativity” and CPS where ERP responses, time-locked to the onset of stressed syllables of “target words”, were measured by computing the *Mean amplitude* in time-windows of 200 ms; N1-P2, ERP responses time-locked to the onsets of words immediately following the “target words” in Type A and Type C respectively, were measured in two consecutive time-windows ([-250–0 ms] and [0–250 ms]).

As for “early negativity”, two fully crossed repeated measures ANOVAs were computed: over midline electrodes including factors Time-windows ([0–200 ms] *vs.* [200–400 ms]), Boundaries (IP *vs.* U), Conditions (boundary *vs.* “no boundary”) and Electrodes (Fz *vs.* Cz *vs.* Pz): and over lateral electrodes, including factors Time-window ([0–200 ms] *vs.* [200–400 ms]), Boundaries (IP *vs.* U), Conditions (boundary *vs.* “no boundary”), Hemispheres (right *vs.* left) and Locations (anterior *vs.* central *vs.* posterior).

As regard to the CPS, two fully crossed repeated measures ANOVAs were computed separately: over midline electrodes including factors Boundaries (IP *vs.* U), Conditions (boundary *vs.* “no boundary”) and Electrodes (Fz *vs.* Cz *vs.* Pz): and over lateral electrodes, including the factors Boundaries (IP *vs.* U), Conditions (boundary *vs.* “no boundary”), Hemispheres (right *vs.* left) and Locations (anterior *vs.* central *vs.* posterior). Figure 57 shows electrodes grouped into regions of interest (ROIs).

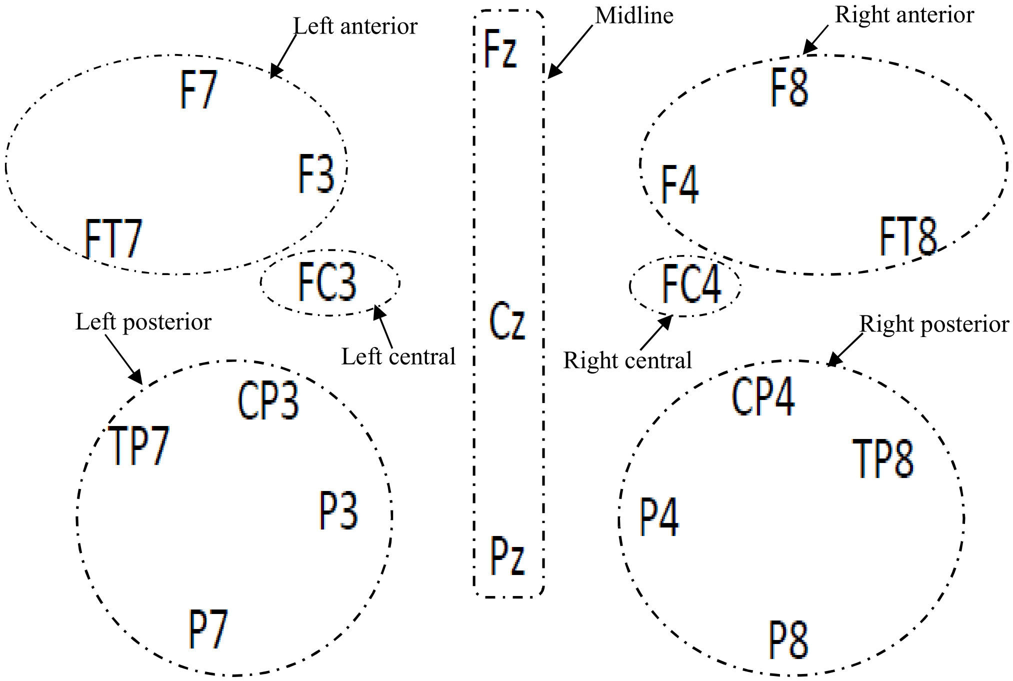


Figure 57: Region of interests (ROIs) grouping electrodes considered for statistical analysis and topographic representation of ERP waveforms.

As regards the N1-P2, two fully crossed repeated measures ANOVAs were computed separately: over midline electrodes including factors Conditions (boundary *vs.* "no boundary") and Electrodes (Fz *vs.* Cz *vs.* Pz): and over lateral electrodes, including the factors Conditions (boundary *vs.* "no boundary"), Hemispheres (right *vs.* left) and Locations (anterior *vs.* central *vs.* posterior).

We only reported results involving the factor "Conditions" since it is directly related to the objectives of this study. Finally, if a significant interaction was found between "Conditions" and any other factor, post-hoc ANOVAs were computed to understand the effect of that factor for each time-window and condition separately.

5.2.1. First analysis ("Early negativity")

We conducted a first analysis for the early negative peak (see Figure 58), possibly marking the onset of the CPS effect elicited in response to the processing of the *IPB* and *UB*. ERP responses were measured by computing the mean amplitude in two consecutive time-windows ([0–200 ms] and [200–400 ms]) in line with the possible occurrence of the "early negativity".

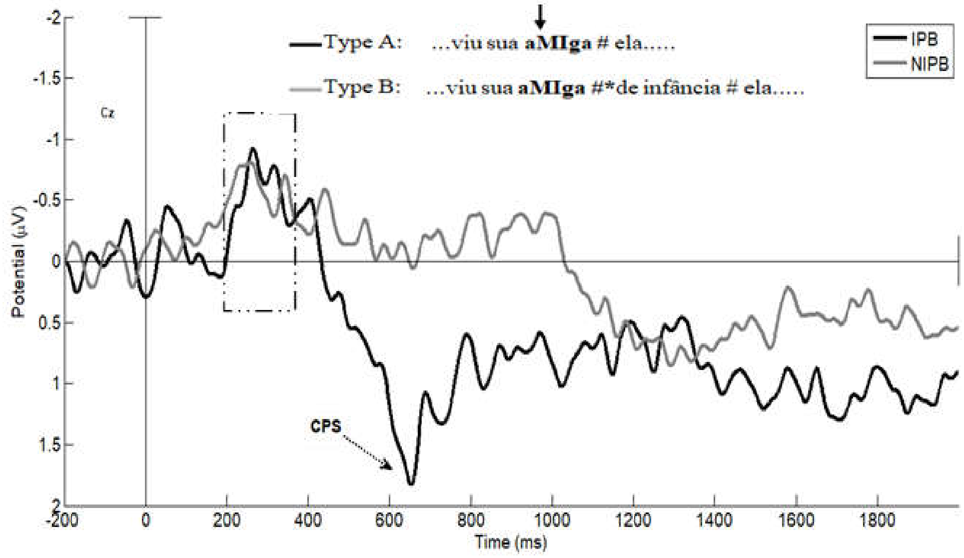


Figure 58: Grand averaged ERPs for IP prosodic boundary and no IP prosodic boundary conditions at Cz electrode. Hash (#) stands for *IPB* and hash asterisk (#*) for *NIPB*. The dotted black rectangle indicates the "Early negativity". For clarity purpose.

5.2.1.1. Results

An overview of the results is presented in Table 3. Only significant differences were reported.

Table 3: Significant effects of ANOVAs for mean amplitudes across time-window of [0–400 ms] for the "early negativity" component of ERPs.

	Midline electrodes			Lateral ROIs		
Tws (ms)	Effect	F(df)	B vs. NB (μV) (Mean (SE))	Effect	F(df)	B vs. NB (μV) (Mean (SE))
0 – 200						
200 – 400				Cond	6.9 (1,1908)**	-0.26 (0.03) < -0.14 (0.03)
				Cond x Hem	18.9 (1,1908)***	
				Left Hem	25.4 (1,954)***	-0.36 (0.04) < -0.06 (0.04)

Tws = time-windows; B = boundary condition; NB = "no boundary" condition; Cond = condition; Hem = hemisphere; x = interaction. (*) stands for $p \leq 0.05$; (**), for $p \leq 0.01$; (***), for $p \leq 0.001$; (>), for greater than; (<), for smaller than.

In sum, the results of this first analysis showed that after the onset of the IP and U prosodic boundaries, there was an "early negativity" significantly more negative in time-window [200–400 ms] as compared to time-window [0–200 ms]. This ERP effect was more pronounced for *IPB* and *UB* over the left hemisphere, as compared to *NIPB* and *NUB*. There were no interactions for boundary type (*IPB* and *UB*) at either midline or lateral electrodes. This indicates that the “early negativity” did not depend on the type of the boundary in the statements.

5.2.2. Second analysis (CPS component of ERPs)

In the second analysis, we analyzed the broad positive deflection we considered to be the CPS component of ERPs evoked in response to processing of IP and U prosodic boundaries. The ERP responses were measured by computing the mean amplitude in four consecutive time-windows (400–600, 600–800, 800–1000 and 1000–1200 ms) in line with the possible occurrence of the CPS response to *IPB* (from ~500 to 1200 ms) and *UB* (from ~600 to 1200 ms).

5.2.2.1. Results

An overview of the results is presented in Table 4. Only significant differences were reported.

Table 4: Significant effects of ANOVAs for mean amplitudes across time-window of [400–1200 ms] for the CPS component of ERPs.

	Midline electrodes			Lateral ROIs		
Tws (ms)	Effect	*F*(df)	B vs. NB (µV) (Mean (SE))	Effect	*F*(df)	B vs. NB (µV) (Mean (SE))
400 – 600	Cond	4.2 (1,348)*	0.22 (0.08) > -0.1 (0.07)			
	Cond x Boun	5.5 (1,348) **				
	IP	10.5 (1,178)**	0.37 (0.1) > -0.14 (0.11)			
600 – 800	Cond	23.2 (1,348)***	0.68 (0.10) > 0.03 (0.08)	Cond	10.2 (1,1896)**	0.05 (0.0) > -0.14 (0.04)
	Cond x Elec	3.9 (2,348)*		Cond x Hem	11.9 (1,1896)***	
	Cz	19.4 (1,118)***	1.05 (0.1) > 0.01 (0.1)	Right Hem	19.9 (1,958)***	0.24 (0.0) > -0.17 (0.06)
	Pz	12.6 (1, 118)**	0.5 (0.14) > -0.1 (0.1)	Cond x Boun	6.6 (1,1896)**	
				IP	9.9 (1,958)***	0.14 (0.07) > -0.14 (0.05)
800–1000	Cond	9.7 (1,348)***	0.45 (0.11) > 0.007 (0.08)	Cond	31.6 (1,1896)***	0.16 (0.05) > -0.22 (0.04)
	Cond x Elec	4.4 (2,348)**		Cond x Hem	14.6 (1,1896)***	
	Cz	11.2 (1,118)**	0.7 (0.18) > -0.02 (0.15)	Right Hem	40.5 (1,958)***	0.37 (0.07) > -0.27 (0.06)
	Pz	9 (1,118)**	0.44 (0.15) > -0,19 (0.14)			
1000–1200				Cond	32.3 (1,1896)***	0.24 (0.05) > -0.19 (0.05)
				Cond x Hem	6.7 (1,1896)**	
				Right Hem	31.4 (1,958)***	0.38 (0.08) > -0.24 (0.07)
				Cond x Loca	9.18 (2,1896) ***	
				Anterior Loca	25.8 (1,718)***	0.34 (0.1) > -0.4 (0.1)
				Central Loca	10.4 (1,238)**	0.4 (0.1) > -0.13 (0.1)

Tws = time-windows; B = boundary condition; NB = “no boundary” condition; Cond = condition; Hem = hemisphere; Elec = electrode; Boun = boundary; Loca = location; x = interaction. (*) stands for p≤ 0.05; (**), for p≤ 0.01; (***), for p≤ 0.001; ; (>), for greater than; (<), for smaller than.

In sum, the analysis on midline electrodes showed a CPS in response to the IP prosodic boundary at all electrodes (Fz, Cz, Pz) in time-window [400–600 ms] (Amplitude, M= 0.37 μV, SE= 0.1). The CPS was only observed at Cz, Pz for both the IP and U prosodic boundaries in time-window [600–1000 ms] and presented relatively different amplitudes (*IPB*: Amplitude, M= 0.7 μV, SE= 0.1; *UB*: Amplitude, M= 0.6 μV, SE= 0.1). At lateral electrodes, the analysis showed a CPS for the IP prosodic boundary in time-window [600–1200 ms] over the right hemisphere (Amplitude, M= 0.4 μV, SE= 0.07) and more pronounced at central and anterior locations. For the U prosodic boundary, the CPS was observed in time-window [800–1200 ms] over the same hemisphere and locations. For both the IP and U prosodic boundaries, in time-window [800-1200 ms], the CPS also showed relatively different amplitudes (*IPB*: Amplitude, M= 0.4 μV, SE= 0.09; *UB*: Amplitude, M= 0.3 μV, SE= 0.06). At both midline and lateral electrodes, we observed that the factor Boundaries (IP *vs.* U) interacted with the factor Conditions in different time-windows. This is an indication that the onset latency, amplitude (to some extent) and duration of the CPS effect varied as a function of type of boundary in the statement.

5.2.3. Third analysis (N1-P2 components of ERPs)

An overview of the results is presented in Table 5. Only significant differences were reported.

Table 5: Significant effects of ANOVAs for mean amplitudes across time-window of [-250–250 ms] for the N1-P2 component of ERPs.

	Midline electrodes			Lateral ROIs		
Tws (ms)	Effect	*F*(df)	B vs. NB (μV) (Mean (SE))	Effect	*F*(df)	B vs. NB (μV) (Mean (SE))
-250–0	Cond	4.18 (1,174)*	0.02 (0.01) > -0.03 (0.02)	Cond	7.7 (1,948)**	0.014 (0.005) > -0.012 (0.007)
0–250				Cond	4.43 (1,948)*	0.23 (0.04) > 0.1 (0.04)
				Cond x Hem	8.8 (1,948)**	
				Right Hem	13.7 (1,478)***	0.4 (0.05) > 0.08 (0.06)
				Cond x Loca	4.7 (2,948)**	
				Anterior Loca	14.2 (1,178)**	0.47 (0.1) > -0.16 (0.1)

Tws = time-windows; B = boundary condition; NB = “no boundary” condition; Cond = condition; Hem = hemisphere; Elec = electrode; Loca = location; x = interaction. (*) stands for p≤ 0.05; (**), for p≤ 0.01; (***), for p≤ 0.001; (>), for greater than; (<), for smaller than.

In sum, the analysis at midline and lateral electrodes showed ERP responses to the boundary condition with a significantly larger positivity in both time-windows (with [-250–0 ms] < [0–250 ms] in terms of amplitude value) as compared to "no boundary" conditions. These positive ERP responses were more pronounced at the right hemisphere and at the anterior location, in line with the scalp distribution of the CPS. This indicated that the positivity in response to processing of *UB* started before the onset of words immediately following the prosodic boundaries and later merged with the N1-P2 responses to onsets of those words. We suggest that, to a large extent, this contributed to the relatively higher amplitude observed in time-window [0–250 ms].

6. DISCUSSION

The objectives of this study were to use ERPs to investigate if acoustic cues marking intonational phrase and utterance boundaries in Brazilian Portuguese statements elicit a CPS and do a comparison of this ERP component at boundaries of these two prosodic constituents. We presented 30 native Brazilian Portuguese-speaking adult students with three types of statements: Type A, with *IPB* and *UB*; Type B and Type C composed of similar statements with no prosodic boundaries.

We found that, after the onset of the IP boundary, a significantly more positive ERP component was elicited from ~400 to ~1000 ms at midline electrodes and from ~600 to ~1200 ms over right hemisphere electrodes, central and anterior locations, as compared to the ERP response to the same portion of the sentence with no IP boundary. For the U boundary, after the onset, a more positive ERP was elicited from ~600 to ~1000 ms at midline electrodes and from ~800 to ~1200 ms, over the same hemisphere and locations from ~1000 to ~1200 ms, as compared to the ERP response to the same portion of the sentence with no U boundary.

We argued that the positivity at IP and U boundaries could be either an ERP response to the prosodic boundary processing (CPS), an enhanced N1-P2 response to the onset of the post-boundary word (following a pause) or a combination of the two. In order to disentangle the CPS from the N1-P2 response, only for the U boundary, which is marked by an "interval of silence" long enough (greater than 150 ms) to be considered a pause following Kowal et al. (1983), we conducted a second analysis in the time-window [-250−250 ms] considering the onset of the immediate post-boundary word. With this time-window, we could differentiate the ERP responses that started prior to the onset of the post-boundary word, in time-window [-250−0 ms], where the acoustic cues marking the U boundary are available (pre-final syllable lengthening, pitch variation and pause) from the ERP responses that started after the onset of the post-boundary word, in time-window [0−250 ms], where the N1-P2 response to the onset of the post-boundary word overlapped with the ERP response to the previous prosodic boundary. This second analysis showed that the positivity at the U boundary started before the onset of the post-boundary word and later merged with the N1-P2 response. We could therefore conclude that the positive shift observed after the onset of the prosodic boundary does not appear to only reflect an N1-P2 response to speech onset after the pause. Instead, this positive shift consisted of another ERP component apparently in response to processing of the U boundary. Consequently, we assumed that the broad positive deflection of ERPs we observed in our analysis is the CPS (Closure-Positive-Shift) in response to processing of IP and U prosodic boundaries in the statements.

Also, prior to the CPS response to the processing of prosodic boundaries, from ~200 to ~400 ms after the onset of the stressed syllables of “target words” for *IPB* and *UB*, we found an early negative peak which was more pronounced over left hemisphere electrodes. We considered that this ERP effect is the pre-CPS negativity also observed in previous studies (PANNEKAMP et al., 2005; KERKHOFS et al., 2008; BÖGELS et al., 2010; PAUKER et al., 2011). This “early negativity” may be a consequence of the processing of early prosodic cues marking prosodic boundaries. Since it was also observed for *NIPB* and *NUB*, one could suggest that it is triggered by the neural effort associated with the expectation of a prosodic boundary, due to the linguistic knowledge of the listeners in the experiment. The less-pronounced negativity we observed for *NIPB* and *NUB* is certainly due to the fact that prosodic boundaries eventually did not occur.

To our knowledge, this is the first study to compare the CPS effects at the boundaries of the two highest prosodic constituents and to report this ERP component in statements with adult native Brazilian Portuguese speakers. The results first revealed that ERP responses to the processing of prosodic boundaries were preceded by an “early negativity”. The more pronounced left hemisphere scalp distribution of the “early negativity” is in line with previous findings (PANNEKAMP et al., 2005; KERKHOFS et al., 2008; BÖGELS et al., 2010), although notably, Pauker et al. (2011) found a right-lateralized pre-CPS negativity.

In line with previous ERP studies (STEINHAUER et al., 1999; STEINHAUER & FRIEDERICI, 2001; PANNEKAMP et al., 2005; PETER et al., 2014) on prosodic boundary processing in normal sentences, the present study reports that the CPS is elicited in Brazilian Portuguese under listening conditions as a marker of intonational phrase and utterance boundaries. The comparison of this ERP component for the *IPB* and the *UB* revealed interesting findings. As regards the scalp distribution, both the CPS effects for the *IPB* and the *UB* were reported at midline, central, anterior and more pronounced over right hemisphere electrodes. This is an indication that the phonetic strength differences (as reflected in acoustic analysis) between the set of prosodic cues marking these two distinct prosodic constituents did not interact with the scalp distribution of the CPS. Interestingly, the more pronounced right hemisphere distribution of the CPS we found is in line with the scalp distribution of prosodic-related ERPs as presented in Friederici's model of auditory sentence comprehension (FRIEDERICI, 2011, p. 1378). In addition, Pannekamp et al. (2005) reported right hemisphere distribution of the CPS using jabberwocky sentences, pseudo sentences and hummed sentences. Furthermore, the reported fronto-central distribution for English sentences (*i.e.*, ITZHAK et al., 2010, p. 10), bilateral and largely midline (BÖGELS et al., 2011, p. 428) scalp distribution of the CPS corroborate the midline, anterior and central location scalp distribution we found. Though the scalp distribution of the CPS varies to some extent over studies – probably as a function of experimental variation and of stimulus conditions (PANNEKAMP et al., 2005, p. 6) – we can state that CPS effects are not only reported with a broad distribution over the whole scalp (e.g, STEINHAUER et al., 1999; KERKHOFS et al., 2007), but also with more specific locations, including a centro-parietal distribution for German sentences (STEINHAUER & FRIEDERICI, 2001a).

Regarding onset latency, amplitude and duration, the phonetic strength differences between the set of acoustic prosodic cues marking *IPB* and *UB* interacted with the elicitation of the CPS effect. Notably, the onset latency estimates came from a visual inspection of the grand averages which we substantiated with statistical analysis. At midline electrodes, the CPS for the *IPB* appeared to show an early onset (~400 ms), longer duration (~600 ms) and higher amplitude (up to M= 0.7 μV, SE= 0.1) as compared to the CPS for the *UB* with a late onset (~600 ms), shorter duration (~400 ms) and lower amplitude (up to M= 0.6 μV, SE= 0.1). At lateral electrodes as well, over the right hemisphere at central and anterior locations, the CPS for the *IPB* appeared to show an early onset (~600 ms), longer duration (~600 ms) and higher amplitude (up to M= 0.4 μV, SE= 0.09) as compared to the CPS for the *UB* with a late onset (~800 ms), shorter duration (~400 ms) and lower amplitude (up to M= 0.3 μV, SE= 0.06). These onset latencies of the CPS are, to a large extent, in line with previous studies (STEINHAUER et al., 1999; PANNEKAMP et al., 2005), where the CPS was present around 500 ms after the onset of the IP boundary. Also, the durations are, to a large extent, in line with the 500 to 700 ms duration of CPS effect observed in previous research (STEINHAUER et al., 1999; PAUKER et al., 2011). Notably, these comparisons were cautiously established since, unlike in the current study, most other researches did not time-lock the CPS to the onset of the pre-boundary stressed syllable.

Importantly, these observations substantiated the hypothesis we formulated concerning the modulation (with respect to the onset latency, amplitude and duration) of the CPS, as a function of phonetic strength differences between the same set of acoustic cues marking *IPB* and *UB* in the statements we used. The early onset latency, longer duration and relatively higher amplitude of the CPS effect for the *IPB* as compared to the late onset latency, reduced duration and lower amplitude for the *UB*, is possibly an indication that the acoustic prosodic cues signaling both boundaries varied and were processed in different ways. Also, since the information (stimuli) varied structurally and semantically, we suggest that other factors could be involved. Thus, given the complex nature of ERP waves and language processing, it could be argued that effects and experimental manipulation should correlate, but components and cognitive functions should not equate (LUCK, 2005; SOTO, 2014).

We used a time-window of [0−200 ms] in our analysis and probably a smaller time-window, *i.e.,* [0−100 ms] could have permitted a finer analysis of the temporal processing of *IPB* and *UB*. Crucially, *IPB* was marked by two major acoustic cues (pre-final syllable lengthening and pitch variation), while *UB*, in addition to these cues, was marked by a pause. Aside from the pause – which does not trigger the CPS per se (STEINHAUER et al., 1999) – acoustic analysis showed that acoustic cues marking the two boundaries differed with respect to pre-final syllable lengthening, pitch variation, mean F0 and mean intensity pattern (realized in the pre-boundary word). *IPB* was marked by longer pre-final syllable lengthening (realized in pre-boundary stressed syllable), by a rising nuclear contour (higher mean F0, higher mean intensity realized in pre-boundary stressed syllable and higher pitch variation, higher mean F0, higher mean intensity realized in post-stressed syllable) characterizing a “continuative tone”, as compared to *UB,* which was marked by lesser pre-final syllable lengthening, by a falling nuclear contour (or final fall) characterizing a “declarative statement” (TENANI, 2002; FROTA & MORAES, 2016). Presumably, these acoustic cues guided listeners in detecting that IP and U boundaries coincided with clause and utterance boundaries, respectively, in the statements we used. Since previous studies supported the idea that the CPS is primarily elicited by acoustic prosodic cues (BROUWER, FITZ & HOEKS, 2012), while linguistic cues modulate its amplitude and scalp topography (KERKHOFS et al., 2007), we suggested that CPS effects found at IP and U boundaries were exclusively elicited by acoustic prosodic cues, while linguistic information (*i.e.*, syntactic and semantic) differences characterizing subordinate and main clauses modulated the onset latency, amplitude and duration.

According to Kerkhofs et al. (2008), the CPS amplitude is modulated as a function of the salience of prosodic boundary markers. This presumption suggests that the "continuative tone" characterized by the boundary tone – longer pre-final lengthening (in pre-boundary stressed syllable), pitch rise and higher intensity (in pre-boundary stressed and post-stressed syllable) – marking the *IPB,* triggered the higher CPS amplitude we found as compared to the lower CPS amplitude for *UB,* which was marked by the boundary tone – less pre-final lengthening (in pre-boundary stressed syllable), pitch fall and lower intensity (in pre-boundary stressed and post-stressed syllable) – characterizing a "declarative statement". Hence, this phonetic strength difference seems to be the most probable factor to explain the relative CPS amplitude difference existing between *IPB* and *UB.* Apparently, listeners were sensitive to the prosodic pattern differences between *IPB* and *UB*.

A plausible account for the onset latency difference might, as well, be the phonetic strength differences. The early CPS onset latency for *IPB* as compared to *UB* might reflect an early processing for acoustic prosodic cues marking *IPB*. This could be mainly explained by the fact the pre-boundary stressed syllable – marking the onset of the prosodic boundary – for *IPB,* as compared to *UB*, had more salient acoustic cues including longer lengthening, higher mean F0 and higher mean intensity. This appears to have triggered an early CPS effect for *IPB* as compared to *UB.*

As for the duration difference, we suggested that the CPS duration varied as a function of its amplitude modulation. As reflected in acoustic analysis, the manifestation in acoustic phonetic cues is that *IPB* was marked by a longer pre-final syllable lengthening (in pre-boundary stressed syllable) as compared to *UB,* resulting in a much longer salience of acoustic prosodic markers reported for *IPB.* Thus, the CPS duration difference may be attributable to the pre-final syllable lengthening difference between *IPB* and *UB*. We argued that pre-final lengthening, as an acoustic prosodic cue, may exclusively have durational effects on the salience of acoustic prosodic cues marking the prosodic boundaries. Taking the whole discussion into consideration, we may conclude that the amplitude, onset latency and duration of the CPS effects reflected the extent to which acoustic prosodic cues were activated, in keeping with previous findings (STEINHAUER & FRIEDERICI, 2001; STEINHAUER, 2003).

The results discussed in this study could be relevant in researches on communication disorders. The American Speech-Language-Hearing Association (ASHA) (1993) has defined communication disorder as an impairment in the ability to receive, send, process, and comprehend concepts or verbal, nonverbal and graphic symbol systems. The cause of communication disorder may be related to biological problems such as brain lesions or development abnormalities, or possibly by exposure to toxins during pregnancy. ASHA (2013) presented different communication disorders as follows: a) **speech disorder,** defined as an impairment of the articulation of speech sounds, fluency and/or voice; b) **language disorder**, an impaired comprehension and/or use of spoken, written and/or other symbol systems (may involve the form, content and function of language in communication); c) **hearing disorder**, is the result of impaired auditory sensitivity of the physiological auditory system; and d) **Central Auditory Processing Disorders (CAPD),** refer to limitations in the continuous transmission, analysis, organization, transformation, elaboration, storage, retrieval, and use of information contained in audible signals. CAPD may involve the listener's active and passive ability to do the following: i) attend, discriminate, and identify acoustic signals; ii) transform and continuously transmit information through both the peripheral and central nervous systems; iii) filter, sort, and combine information at appropriate perceptual and conceptual levels; iv) store and retrieve information efficiently; restore, organize, and use retrieved information; v) segment and decode acoustic stimuli using phonological, semantic, syntactic, and pragmatic knowledge; and vi) attach meaning to a stream of acoustic signals through use of linguistic and nonlinguistic contexts.

Considering the above brief review on communication disorders, we recalled that it has been shown broadly in this study that prosodic boundaries facilitates syntactic structure representation and semantic identification of the speech units and explains the speaker's intentions towards his audience. The ability of an individual to process the acoustic cues marking prosodic boundaries, therefore, would play a significant role in effective speech communication with others. In that regard, this study investigated, by way of ERP experiment, the modulation of brain electrical signals correlates for prosodic boundaries at phrase and sentence levels, in terms of onset latency, duration, amplitude and scalp distribution. We may argue that the results of our investigation, specifically, are relevant findings related to the discussion on Central auditory processing disorders (CAPD) and, generally, constitute contributing findings to researches on communication disorders.

7. CONCLUSION

The results of the current thesis show that a CPS effect is elicited by acoustic prosodic cues marking prosodic boundaries at different levels in normal Brazilian Portuguese statements. An auditory ERP paradigm tasking participant to actively comprehend the presented stimuli was used in the experiment. The CPS appears to be a reliable online reflection of phonological sentence phrasing in native Brazilian Portuguese speakers. Notably, the CPS effect for the intonational phrase boundary was different as compared to the utterance boundary, in terms of amplitude, onset latency and duration. It occurred that this CPS modulation was dependent on the phonetic strength differences between the same set of acoustic cues marking the two distinct prosodic boundaries in the statements. These results suggest that listeners are sensitive to phonetic strength differences between these same acoustic prosodic cues. Thus, we may propose that, in sentence comprehension, processing of syntactic structure representation and semantic identification requires that the human brain detects and processes phonetic strength modulations of acoustic signals marking speech chunks.

From a linguistic perspective, the results of this study could constitute a contribution to research in the area of ICT (Information and Communication Technology). As regard to human-machine interaction, several studies seek to improve artificial intelligence. One of the fundamental concerns is to get machines to properly process and reproduce acoustic signals associated with the segmentation and organization of human speech. On the other hand, from a clinical point of view, the results could also constitute valuable contributions to studies on communication disorders. Particularly with respect to the individual's ability to process acoustic signals associated with the segmentation of linguistic information.

Future research might be necessary. Although the CPS is not triggered by the pause at the intonational phrase boundary per se, as has been observed with the results in this thesis, it may modulate its onset latency and amplitude (LI & YANG, 2009). Therefore, it could be interesting to investigate the extent to which this acoustic parameter – pause – has effects on the modulation of the CPS. In a new experimental paradigm, stimuli would present intonational phrase and utterance boundaries marked by same three major acoustic cues, including pause, pre-final syllable lengthening and pitch range. The pause would be an "interval of silence" that would be controlled (equal at both the prosodic boundaries) in a way that would not affect the naturalness of the stimuli.

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Taylor & Francis Group, 2017.

APENDIX I: The experimental material

1a/ Como Ana gosta de esportes, construiu uma piscina. Ela nada em casa agora.

1b/ Como Ana gosta de esportes aquáticos, construiu uma piscina. Ela nada em casa agora.

1c/ Como Ana gosta de esportes, construiu uma piscina olímpica. Ela nada em casa agora.

2a/ Quando elas pegaram a cadeira, quebraram a garrafa. Elas foram desatentas.

2b/ Quando elas pegaram a cadeira de plástico, quebraram a garrafa. Elas foram desatentas.

2c/ Quando elas pagaram a cadeira, quebraram a garrafa térmica. Elas foram desatentas.

3a/ Desde que fizemos o conserto, a pia não deu problema. Estamos satisfeitos.

3b/ Desde que fizemos o conserto hidráulico, a pia não deu problema. Estamos satisfeitos.

3c/ Desde que fizemos o conserto, a pia não deu problema de vazamento. Estamos satisfeitos.

4a/ Como Diego leu a resenha, ele respondeu às perguntas. Passou no teste.

4b/ Como Diego leu a resenha do livro, ele respondeu às perguntas. Passou no teste.

4c/ Como Diego leu a resenha, ele respondeu às perguntas difíceis. Passou no teste.

5a/ Como podia haver um confronto, não fomos ver o protesto. Era arriscado.

5b/ Como podia haver um confronto violento, não fomos ver o protesto. Era arriscado.

5c/ Como podia haver um confronto, não fomos ver o protesto estudantil. Era arriscado.

6a/ Como danificou o teclado, não terminou o resumo. Não podia usar o computador.

6b/ Como danificou o teclado novo, não terminou o resumo. Não podia usar o computador.

6c/ Como danificou o teclado, não terminou o resumo do livro. Não podia usar o computador.

7a/ Enquanto faço minhas tarefas, minha mãe faz o almoço. Nós cuidamos bem da casa.

7b/ Enquanto faço minhas tarefas diárias, minha mãe faz o almoço. Nós cuidamos bem da casa.

7c/ Enquanto faço minhas tarefas, minha mãe faz o almoço da família. Nós cuidamos bem da casa.

8a/ Como já consertou a gaveta, sempre guarda as canetas. Ele é cuidadoso.

8b/ Como já consertou a gaveta da mesa, sempre guarda as canetas. Ele é cuidadoso.

8c/ Como já consertou a gaveta, sempre guarda as canetas plásticas. Ele é cuidadoso.

9a/ Assim que acabou a palestra, nós limpamos as cadeiras. Elas estavam sujas.

9b/ Assim que acabou a palestra do dia, nós limpamos as cadeiras. Elas estavam sujas.

9c/ Assim que acabou a palestra, nós limpamos as cadeiras da sala. Elas estavam sujas.

10a/ Assim que iniciou o assunto, eles fizeram seus pedidos. O momento foi oportuno.

10b/ Assim que iniciou o assunto esperado, eles fizeram seus pedidos. O momento foi oportuno.

10c/ Assim que iniciou o assunto, eles fizeram seus pedidos formais. O momento foi oportuno.

11a/ Como nunca mais viu a Camila, Paulo ficou com saudades. Eles são bons amigos.

11b/ Como nunca mais viu a Camila Pitanga, Paulo ficou com saudades. Eles são bons amigos.

11c/ Como nunca mais viu a Camila, Paulo ficou com saudades profundas. Eles são bons amigos.

12a/ Assim que assinou o contrato, Bruno recebeu um retorno. Ele fechou um bom negócio.

12b/ Assim que assinou o contrato empresarial, Bruno recebeu um retorno. Fechou um bom negócio.

12c/ Assim que assinou o contrato, Bruno recebeu um retorno financeiro. Ele fechou um bom negócio.

13a/ Assim que recebemos o aumento, agradecemos à imprensa. Ela noticiou nosso protesto.

13b/ Assim que recebemos o aumento salarial, agradecemos à imprensa. Ela noticiou nosso protesto.

13c/ Assim que recebemos o aumento, agradecemos à imprensa nacional. Ela noticiou nosso protesto.

14a/ Desde que construiu a escola, não parou de doar mochilas. Ele é um bom prefeito.

14b/ Desde que construiu a escola experimental, não parou de doar mochilas. Ele é um bom prefeito.

14c/ Desde que construiu a escola, não parou de doar mochilas escolares. Ele é um bom prefeito.

15a/ Como Linda quer fazer Direito, ela visitou o Recife. Vai morar na capital.

15b/ Como Linda quer fazer Direito Internacional, ela visitou o Recife. Vai morar na capital.

15c/ Como Linda quer fazer Direito, ela visitou o Recife de Barreto. Vai morar na capital.

16a/ Como não assistiu à novela, terminou seu trabalho. Ela cumpriu seu dever.
16b/ Como não assistiu à novela favorita, terminou seu trabalho. Ela cumpriu seu dever.
16c/ Como não assistiu à novela, terminou seu trabalho diário. Ela cumpriu seu dever.

17a/ Enquanto eu lia as palavras, eles abriram os cadernos. Focaram na leitura.
17b/ Enquanto eu lia as palavras iniciais, eles abriram os cadernos. Focaram na leitura.
17c/ Enquanto eu lia as palavras, eles abriram os cadernos de aluno. Focaram na leitura.

18a/ Como gostamos de legumes, nós comemos cenoura. Ficamos satisfeitos.
18b/ Como gostamos de legumes cozidos, nós comemos cenoura. Ficamos satisfeitos.
18c/ Como gostamos de legumes, nós comemos cenoura cozida. Ficamos satisfeitos.

19a/ Como falou com o suspeito, ela relatou a conversa. O policial gravou sua fala.
19b/ Como falou com o suspeito do crime, ela relatou a conversa. O policial gravou sua fala.
19c/ Como falou com o suspeito, ela relatou a conversa inteira. O policial gravou sua fala.

20a/ Como não recebeu a herança, ele perdeu a fazenda. Ficou angustiado.
20b/ Como não recebeu a herança milionária, ele perdeu a fazenda. Ficou angustiado.
20c/ Como não recebeu a herança, ele perdeu a fazenda de gado. Ficou angustiado.

21a/ Como Alex se elegeu prefeito, ele vendeu sua empresa. Quer focar na política.
21b/ Como Alex se elegeu prefeito da cidade, ele vendeu sua empresa. Quer focar na política.
21c/ Como Alex se elegeu prefeito, ele vendeu sua empresa de domingo. Quer focar na política.

22a/ Quanto mais Lucas lia seu discurso, mais recebia aplausos. Ele mereceu o elogio.
22b/ Quanto mais Lucas lia seu discurso expositivo, mais recebia aplausos. Ele mereceu o elogio.
22c/ Quanto mais Lucas lia seu discurso, mais recebia aplausos efusivos. Ele mereceu o elogio.

23a/ Como enviaram soldados, venceram a guerrilha. Eles estavam mais equipados.
23b/ Como enviaram soldados americanos, venceram a guerrilha. Eles estavam mais equipados.
23c/ Como enviaram soldados, venceram a guerrilha colombiana. Eles estavam mais equipados.

24a/ Como Laís comprou três sacolas, ela teve um desconto. Está muito feliz.
24b/ Como Laís comprou três sacolas femininas, ela teve um desconto. Está muito feliz.
24c/ Como Laís comprou três sacolas, ela teve um desconto considerável. Está muito feliz.

25a/ Como participará do debate, ele recebeu um aviso. Deve chegar mais cedo.
25b/ Como participará do debate político, ele recebeu um aviso. Deve chegar mais cedo.
25c/ Como participará do debate, ele recebeu um aviso da equipe. Deve chegar mais cedo.

26a/ Quanto mais souber do contexto, mais eu terei certeza. O assunto é complexo.
26b/ Quanto mais souber do contexto histórico, mais eu terei certeza. O assunto é complexo.
26c/ Quanto mais souber do contexto, mais eu terei certeza absoluta. O assunto é complexo.

27a/ Como não tinha coragem, não apresentou o artigo. O assunto era complexo.
27b/ Como não tinha coragem necessária, não apresentou o artigo. O assunto era complexo.
27c/ Como não tinha coragem, não apresentou o artigo científico. O assunto era complexo.

28a/ Assim que Alex viu a menina, ofereceu sua ajuda. Ela andava com dificuldade.
28b/ Assim que Alex viu a menina ferida, ofereceu sua ajuda. Ela andava com dificuldade.
28c/ Assim que Alex viu a menina, ofereceu sua ajuda médica. Ela andava com dificuldade.

29a/ Como eu farei uma filmagem, levarei nossa equipe. Estou muito empolgado.
29b/ Como eu farei uma filmagem complexa, levarei nossa equipe. Estou muito empolgado.
29c/ Como eu farei uma filmagem, levarei nossa equipe completa. Estou muito empolgado.

30a/ Como Lucas fumava cigarro, ele irritou a plateia. A fumaça era insuportável.
30b/ Como Lucas fumava cigarro de palha, ele irritou a plateia. A fumaça era insuportável.
30c/ Como Lucas fumava cigarro, ele irritou a plateia da casa. A fumaça era insuportável.

31a/ Como Ciro reformou a cozinha, ele agradou à esposa. Ela ficou satisfeita.
31b/ Como Ciro reformou a cozinha antiga, ele agradou à esposa. Ela ficou satisfeita.
31c/ Como Ciro reformou a cozinha, ele agradou à esposa querida. Ela ficou satisfeita.

32a/ Como sofreu uma fratura, não subiu a montanha. Ele não podia andar.
32b/ Como sofreu uma fratura séria, não subiu a montanha. Ele não podia andar.
32c/ Como sofreu uma fratura, não subiu a montanha íngreme. Ele não podia andar.

33a/ Assim que Décio viu seu parceiro, ele lhe deu um abraço. Saíram para almoçar.

33b/ Assim que Décio viu seu parceiro de negócios, ele lhe deu um abraço. Saíram para almoçar.

33c/ Assim que Décio viu seu parceiro, ele lhe deu um abraço caloroso. Saíram para almoçar.

34a/ Como Alma liderou a disputa, recebeu a medalha. Ela gostou do prêmio.

34b/ Como Alma liderou a disputa nacional, recebeu a medalha. Ela gostou do prêmio.

34c/ Como Alma liderou a disputa, recebeu a medalha desejada. Ela gostou do prêmio.

35a/ Como Berto sonegou impostos, ele cometeu um delito. Teve que pagar multa.

35b/ Como Berto sonegou impostos federais, ele cometeu um delito. Teve que pagar multa.

35c/ Como Berto sonegou impostos, ele cometeu um delito grave. Teve que pagar multa.

36a/ Assim que Dante bateu na abelha, ele sofreu uma picada. Ficou com a mão inchada.

36b/ Assim que Dante bateu na abelha rainha, ele sofreu uma picada. Ficou com a mão inchada.

36c/ Assim que Dante bateu na abelha, ele sofreu uma picada do inseto. Ficou com a mão inchada.

37a/ Depois que César bateu o recorde, ele falou com o repórter. Estava emocionado.

37b/ Depois que César bateu o recorde mundial, ele falou com o repórter. Estava emocionado.

37c/ Depois que César bateu o recorde, ele falou com o repórter esportivo. Estava emocionado.

38a/ Como Fred fez uma aposta, ele assistiu ao sorteio. Perdeu seu dinheiro.

38b/ Como Fred fez uma aposta arriscada, ele assistiu ao sorteio. Perdeu seu dinheiro.

38c/ Como Fred fez uma aposta, ele assistiu ao sorteio milionário. Perdeu seu dinheiro.

39a/ Como sofreu uma derrota, Aldo quer uma revanche. Acredita que vencerá.

39b/ Como sofreu uma derrota terrível, Aldo quer uma revanche. Acredita que vencerá.

39c/ Como sofreu uma derrota, Aldo quer uma revanche avassaladora. Acredita que vencerá.

40a/ Como vetamos a proposta, não tivemos um acordo. A obra vai parar.

40b/ Como vetamos a proposta indecente, não tivemos um acordo. A obra vai parar.

40c/ Como vetamos a proposta, não tivemos um acordo judicial. A obra vai parar.

41a/ Como Luna tinha uma pistola, atirou no bandido. Ela feriu o ladrão.

41b/ Como Luna tinha uma pistola carregada, atirou no bandido. Ela feriu o ladrão.

41c/ Como Luna tinha uma pistola, atirou no bandido da rua. Ela feriu o ladrão.

42a/ Como distorceu sua imagem, Jair processou a revista. Ele procurou a justiça.
42b/ Como distorceu sua imagem pública, Jair processou a revista. Ele procurou a justiça.
42c/ Como distorceu sua imagem, Jair processou a revista Veja. Ele procurou a justiça.

43a/ Como conhecia as atrizes, Renan resolveu o conflito. Conseguiu acalmá-las.
43b/ Como conhecia as atrizes famosas, Renan resolveu o conflito. Conseguiu acalmá-las.
43c/ Como conhecia as atrizes, Renan resolveu o conflito interminável. Conseguiu acalmá-las.

44a/ Como René bebeu cerveja, incomodou os colegas. Ele estava bêbado.
44b/ Como René bebeu cerveja fortificada, incomodou os colegas. Ele estava bêbado.
44c/ Como René bebeu cerveja, incomodou os colegas de trabalho. Ele estava bêbado.

45a/ Como Clara não tinha recursos, ela viajou de carona. Pediu ajuda a amigos.
45b/ Como Clara não tinha recursos financeiros, ela viajou de carona. Pediu ajuda a amigos.
45c/ Como Clara não tinha recursos, ela viajou de carona solidária. Pediu ajuda a amigos.

46a/ Como Levi não gosta de fritura, ele não comeu a batata. Pediu arroz somente.
46b/ Como Levi não gosta de fritura com azeite, ele não comeu a batata. Pediu arroz somente.
46c/ Como Levi não gosta de fritura, ele não comeu a batata frita. Pediu arroz somente.

47a/ Ainda que ele tenha vontade, não decorará a receita. Ele tem uma memória curta.
47b/ Ainda que ele tenha vontade imensa, não decorará a receita. Ele tem uma memória curta.
47c/ Ainda que ele tenha vontade, não decorará a receita do bolo. Ele tem uma memória curta.

48a/ Como Vitor passou no concurso, conseguiu um emprego. Realizou seu sonho.
48b/ Como Vitor passou no concurso público, conseguiu um emprego. Realizou seu sonho.
48c/ Como Vitor passou no concurso, conseguiu um emprego de técnico. Realizou seu sonho.

49a/ Assim que Paula viu sua amiga, ela fechou a janela. Foi abrir a porta.
49b/ Assim que Paula viu sua amiga de infância, ela fechou a janela. Foi abrir a porta.
49c/ Assim que Paula viu sua amiga, ela fechou a janela da sala. Foi abrir a porta.

50a/ Como Marcos adora farinha, ele comprou um terreno. Vai cultivar mandioca.

50b/ Como Marcos adora farinha de mandioca, ele comprou um terreno. Vai cultivar mandioca.

50c/ Como Marcos adora farinha, ele comprou um terreno imenso. Vai cultivar mandioca.

51a/ Como se protegeu dos mosquitos, não sofreu com coceiras. Ele evitou as picadas.

51b/ Como se protegeu dos mosquitos da dengue, não sofreu com coceiras. Ele evitou as mordidas.

51c/ Como se protegeu dos mosquitos, não sofreu com coceiras irritantes. Ele evitou as mordidas.

52a/ Como o carro não tinha espaço, eu não trouxe as lembranças. Ficaram em casa.

52b/ Como o carro não tinha espaço suficiente, eu não trouxe as lembranças. Ficaram em casa.

52c/ Como o carro não tinha espaço, eu não trouxe as lembranças do passeio. Ficaram em casa.

53a/ Assim que Luiz sofreu o ataque, ele recebeu socorro. Foi medicado em casa.

53b/ Assim que Luiz sofreu o ataque cardíaco, ele recebeu socorro. Foi medicado em casa.

53c/ Assim que Luiz sofreu o ataque, ele recebeu socorro de urgência. Foi medicado em casa.

54a/ Como Aline não faz intrigas, ela evitou a fofoca. Não gosta de polêmicas.

54b/ Como Aline não faz intrigas desnecessárias, ela evitou a fofoca. Não gosta de polêmicas.

54c/ Como Aline não faz intrigas, ela evitou a fofoca dos vizinhos. Não gosta de polêmicas.

55a/ Como sofremos uma manobra, não fizemos nossa campanha. Perdemos as eleições.

55b/ Como sofremos uma manobra da oposição, não fizemos nossa campanha. Perdemos as eleições.

55c/ Como sofremos uma manobra, não fizemos nossa campanha eleitoral. Perdemos as eleições.

56a/ Como Ciro deixou o governo, ele sofreu uma derrota. Não teve apoio partidário.

56b/ Como Ciro deixou o governo federal, ele sofreu uma derrota. Não teve apoio partidário.

56c/ Como Ciro deixou o governo, ele sofreu uma derrota política. Não teve apoio partidário.

57a/ Como José precisou de cuidados, ele chamou a cunhada. Ela é enfermeira.

57b/ Como José precisou de cuidados médicos, ele chamou a cunhada. Ela é enfermeira.

57c/ Como José precisou de cuidados, ele chamou a cunhada do amigo. Ela é enfermeira.

58a/ Como Dante não teve preparo, ele precisou de esforço. Terminou a prova.
58b/ Como Dante não teve preparo adequado, ele precisou de esforço. Terminou a prova.
58c/ Como Dante não teve preparo, ele precisou de esforço mental. Terminou a prova.

59a/ Como não encontraram laranja, eles compraram morango. Precisavam de frutas.
59b/ Como não encontraram laranja lima, eles compraram morango. Precisavam de frutas.
59c/ Como não encontraram laranja, eles compraram morango silvestre. Precisavam de frutas.

60a/ Como Juno apresentou desculpas, ele recebeu conselhos. Aprendeu com os erros.
60b/ Como Juno apresentou desculpas honestas, ele recebeu conselhos. Aprendeu com os erros.
60c/ Como Juno apresentou desculpas, ele recebeu conselhos do pai. Aprendeu com os erros.

61a/ Como Abel recusou a propina, ele recebeu louvores. Foi elogiado.
61b/ Como Abel recusou a propina do político, ele recebeu louvores. Foi elogiado.
61c/ Como Abel recusou a propina, ele recebeu louvores de colegas. Foi elogiado.

62a/ Desde que brigou com a docente, Gil não frequenta a escola. Ele foi suspenso.
62b/ Desde que brigou com a docente de física, Gil não frequenta a escola. Ele foi suspenso.
62c/ Desde que brigou com a docente, Gil não frequenta a escola de línguas. Ele foi suspenso.

63a/ Como ela gosta de brinquedo, sua mãe comprou a boneca. Ficou muito feliz.
63b/ Como ela gosta de brinquedo requintado, sua mãe comprou a boneca. Ficou muito feliz.
63c/ Como ela gosta de brinquedo, sua mãe comprou a boneca Barbie. Ficou muito feliz.

64a/ Como o filme não tinha volume, eles leram a legenda. Assistiram até o fim.
64b/ Como o filme não tinha volume audível, eles leram a legenda. Assistiram até o fim.
64c/ Como o filme não tinha volume, eles leram a legenda exibida. Assistiram até o fim.

65a/ Como Yara perdeu a partida, não recebeu o dinheiro. Ficou desesperada.
65b/ Como Yara perdeu a partida de tênis, não recebeu o dinheiro. Ficou desesperada.
65c/ Como Yara perdeu a partida, não recebeu o dinheiro da aposta. Ficou desesperada.

66a/ Quando nós vimos o pedinte, ele falava com pedestres. Estava sem camisa.

66b/ Quando nós vimos o pedinte amputado, ele falava com pedestres. Estava sem camisa.

66c/ Quando nós vimos o pedinte, ele falava com pedestres curiosos. Estava sem camisa.

67a/ Como eles comem gordura, podem sofrer um infarto. Precisam cuidar da saúde.

67b/ Como eles comem gordura vegetal, podem sofrer um infarto. Precisam cuidar da saúde.

67c/ Como eles comem gordura, podem sofrer um infarto de coração. Precisam cuidar da saúde.

68a/ Como Pedro tem uma fortuna, ele patrocinou o evento. Foi um sucesso total.

68b/ Como Pedro tem uma fortuna imensa, ele patrocinou o evento. Foi um sucesso total.

68c/ Como Pedro tem uma fortuna, ele patrocinou o evento beneficente. Foi um sucesso total.

69a/ Desde que consegui o emprego, eu mudei minha rotina. Estou mais ocupado.

69b/ Desde que consegui o emprego de vigilante, eu mudei minha rotina. Estou mais ocupado.

69c/ Desde que consegui o emprego, eu mudei minha rotina diária. Estou mais ocupado.

70a/ Como Rosa tinha vantagem, ela terminou a corrida. Chegou em terceiro lugar.

70b/ Como Rosa tinha vantagem física, ela terminou a corrida. Chegou em terceiro lugar.

70c/ Como Rosa tinha vantagem, ela terminou a corrida olímpica. Chegou em terceiro lugar.

71a/ Como Alva estuda espanhol, ela pratica com nativos. Melhorou bastante.

71b/ Como Alva estuda espanhol intermediário, ela pratica com nativos. Melhorou bastante.

71c/ Como Alva estuda espanhol, ela pratica com nativos da língua. Melhorou bastante.

72a/ Desde que criaram o estado, experimentaram fracassos. Faltou planejamento.

72b/ Desde que criaram o estado vizinho, experimentaram fracassos. Faltou planejamento.

72c/ Desde que criaram o estado, experimentaram fracassos econômicos. Faltou planejamento.

73a/ Como João não come manteiga, a irmã comprou azeite. Ele gostou do sabor.

73b/ Como João não come manteiga sem sal, a irmã comprou azeite. Ele gostou do sabor.

73c/ Como João não come manteiga, a irmã comprou azeite de oliva. Ele gostou do sabor.

74a/ Como Anita gosta de cachorro, ela comprou uma cadela. Tem companhia agora.

74b/ Como Anita gosta de cachorro de raça, ela comprou uma cadela. Tem uma companhia agora.

74c/ Como Anita gosta de cachorro, ela comprou uma cadela adorável. Tem uma companhia agora.

75a/ Como Débora fez a postagem, ela recebeu insultos. Ficou traumatizada.

75b/ Como Débora fez a postagem polêmica, ela recebeu insultos. Ficou traumatizada.

75c/ Como Débora fez a postagem, ela recebeu insultos de seguidores. Ficou traumatizada.

76a/ Como Natã praticou o assalto, ele se escondeu do agente. Foi preso logo depois.

76b/ Como Natã praticou o assalto a banco, ele se escondeu do agente. Foi preso logo depois.

76c/ Como Natã praticou o assalto, ele se escondeu do agente de segurança. Foi preso logo depois.

77a/ Assim que Tito fez os buracos, deparou-se com insetos. Ficou bastante assustado.

77b/ Assim que Tito fez os buracos necessários, deparou-se com insetos. Ficou bastante assustado.

77c/ Assim que Tito fez os buracos, deparou-se com insetos venenosos. Ficou bastante assustado.

78a/ Como Bento não cobriu a comida, ela atraiu as formigas. Entraram no prato.

78b/ Como Bento não cobriu a comida do jantar, ela atraiu as formigas. Entraram no prato.

78c/ Como Bento não cobriu a comida, ela atraiu as formigas esfomeadas. Entraram no prato.

79a/ Como Batista não viu os clientes, ele fechou o mercado. Esperou muito tempo.

79b/ Como Batista não viu os clientes estrangeiros, ele fechou o mercado. Esperou muito tempo.

79c/ Como Batista não viu os clientes, ele fechou o mercado da aldeia. Esperou muito tempo.

80a/ Como Carlo presenciou o sequestro, ele denunciou os bandidos. A polícia reagiu logo.

80b/ Como Carlo presenciou o sequestro relâmpago, ele denunciou os bandidos. A polícia reagiu logo.

80c/ Como Carlo presenciou o sequestro, ele denunciou os bandidos envolvidos. A polícia reagiu logo.

81a/ Como não preencheu o cadastro, recebeu um alerta. Não entraria no laboratório.

81b/ Como não preencheu o cadastro de estágio, recebeu um alerta. Não entraria no laboratório.

81c/ Como não preencheu o cadastro, recebeu um alerta da escola. Não entraria no laboratório.

82a/ Assim que recebeu o registro, começou a consulta. Atendeu a todos.
82b/ Assim que recebeu o registro dos pacientes, começou a consulta. Atendeu a todos.
82c/ Assim que recebeu o registro, começou a consulta médica. Atendeu a todos.

83a/ Como Eli promoveu o evento, ele apresentou objetos. A exposição foi um sucesso.
83b/ Como Eli promoveu o evento indígena, ele apresentou objetos. A exposição foi um sucesso.
83c/ Como Eli promoveu o evento, ele apresentou objetos tradicionais. A exposição foi um sucesso.

84a/ Como Larissa trouxe banana, nós compramos laranja. Fizemos salada de frutas.
84b/ Como Larissa trouxe banana pacovan, nós compramos laranja. Fizemos salada de frutas.
84c/ Como Larissa trouxe banana, nós compramos laranja pera. Fizemos salada de frutas.

85a/ Quando Gilberto soprou o apito, ele iniciou o desfile. A fila andou logo.
85b/ Quando Gilberto soprou o apito de dedo, ele iniciou o desfile. A fila andou logo.
85c/ Quando Gilberto soprou o apito, ele iniciou o desfile de moda. A fila andou logo.

86a/ Como não conseguiu a licença, não instalaram as barracas. Foi proibido.
86b/ Como não conseguiu a licença da prefeitura, não instalaram as barracas. Foi proibido.
86c/ Como não conseguiu a licença, não instalaram as barracas de praia. Foi proibido.

87a/ Como Mila escutou as sentenças, ela apagou os arquivos. Não quis salvá-los.
87b/ Como Mila escutou as sentenças da pesquisa, ela apagou os arquivos. Não quis salvá-los.
87c/ Como Mila escutou as sentenças, ela apagou os arquivos de som. Não quis salvá-los.

88a/ Como necessitavam de moradia, construíram um abrigo. Planejaram bem.
88b/ Como necessitavam de moradia definitiva, construíram um abrigo. Planejaram bem.
88c/ Como necessitavam de moradia, construíram um abrigo apropriado. Planejaram bem.

89a/ Quando Telma começou a carreira, ela enfrentou um dilema. Não tinha experiência.
89b/ Quando Telma começou a carreira de medicina, ela enfrentou um dilema. Não tinha experiência.
89c/ Quando Telma começou a carreira, ela enfrentou um dilema ético. Não tinha experiência.

90a/ Quando nós vimos o dentista, ele usava uma gravata. Voltava de um evento.

90b/ Quando nós vimos o dentista do bairro, ele usava uma gravata. Voltava de um evento.

90c/ Quando nós vimos o dentista, ele usava uma gravata borboleta. Voltava de um evento.

91a/ Como Luna comprou a escova, ela penteou o cabelo. Adorou o produto de beleza.

91b/ Como Luna comprou a escova elétrica, ela penteou o cabelo. Adorou o produto de beleza.

91c/ Como Luna comprou a escova, ela penteou o cabelo embaraçado. Adorou o produto de beleza.

92a/ Quando Ivo mostrou o desenho, eles gostaram dos conceitos. Aprovaram sua proposta.

92b/ Quando Ivo mostrou o desenho industrial, eles gostaram dos conceitos. Aprovaram sua proposta.

92c/ Quando Ivo mostrou o desenho, eles gostaram dos conceitos ilustrados. Aprovaram sua proposta.

93a/ Desde que Gil encontrou o modelo, ele mudou o estilo. Tornou-se mais vaidoso.

93b/ Desde que Gil encontrou o modelo americano, ele mudou o estilo. Tornou-se mais vaidoso.

93c/ Desde que Gil encontrou o modelo, ele mudou o estilo de roupa. Tornou-se mais vaidoso.

94a/ Como Tiago se juntou à direita, ele vetou o programa. Informou à imprensa local.

94b/ Como Tiago se juntou à direita política, ele vetou o programa. Informou à imprensa local.

94c/ Como Tiago se juntou à direita, ele vetou o programa social. Informou à imprensa local.

95a/ Quando Nilson perdeu o controle, ele atropelou a senhora. Ela saiu ilesa.

95b/ Quando Nilson perdeu o controle do carro, ele atropelou a senhora. Ela saiu ilesa.

95c/ Quando Nilson perdeu o controle, ele atropelou a senhora de bengala. Ela saiu ilesa.

96a/ Depois que observamos os problemas, nós fizemos os ajustes. O texto ficou bom.

96b/ Depois que observamos os problemas de redação, nós fizemos os ajustes. O texto ficou bom.

96c/ Depois que observamos os problemas, nós fizemos os ajustes necessários. O texto ficou bom.

97a/ Como Adriane viu o emblema, ela identificou o sargento. Ele voltava do quartel.
97b/ Como Adriane viu o emblema militar, ela identificou o sargento. Ele voltava do quartel.
97c/ Como Adriane viu o emblema, ela identificou o sargento do exército. Ele voltava do quartel.

98a/ Depois que construíram a barragem, reclamamos do descaso. Teve falta de energia.
98b/ Depois que construíram a barragem hidrelétrica, reclamamos do descaso. Teve falta de energia.
98c/ Depois que construíram a barragem, reclamamos do descaso da empresa. Teve falta de energia.

99a/ Assim que acionou o alarme, ele acordou os cadetes. Fizeram exercícios matinais.
99b/ Assim que acionou o alarme sonoro, ele acordou os cadetes. Fizeram exercícios matinais.
99c/ Assim que acionou o alarme, ele acordou os cadetes do exército. Fizeram exercícios matinais.

100a/ Como Cora fez a faxina, ela limpou a despensa. Removeu alimentos vencidos.
100b/ Como Cora fez a faxina doméstica, ela limpou a despensa. Removeu alimentos vencidos.
100c/ Como Cora fez a faxina, ela limpou a despensa da cozinha. Removeu alimentos vencidos.

101a/ Quando Beto descobriu o esquema, ele procurou a justiça. A lei foi aplicada.
101b/ Quando Beto descobriu o esquema criminoso, ele procurou a justiça. A lei foi aplicada.
101c/ Quando Beto descobriu o esquema, ele procurou a justiça de trabalho. A lei foi aplicada.

102a/ Como convidaram a duquesa, fizeram um banquete. Tinha muita comida.
102b/ Como convidaram a duquesa de Santos, fizeram um banquete. Tinha muita comida.
102c/ Como convidaram a duquesa, fizeram um banquete real. Tinha muita comida.

103a/ Depois que Yuri cortou os arbustos, ele limpou o gramado. É um bom jardineiro.
103b/ Depois que Yuri cortou os arbustos do quintal, ele limpou o gramado. É um bom jardineiro.

103c/ Depois que Yuri cortou os arbustos, ele limpou o gramado do quintal. É um bom jardineiro.

104a/ Como Alva presenciou o delito, ajudou com o retrato. O criminoso foi preso.

104b/ Como Alva presenciou o delito de estelionato, ajudou com o retrato. O criminoso foi preso.

104c/ Como Alva presenciou o delito, ajudou com o retrato falado. O criminoso foi preso.

105a/ Como divulgaram o retrato, resolveram o delito. O suspeito foi denunciado.

105b/ Como divulgaram o retrato falado, resolveram o delito. O suspeito foi denunciado.

105c/ Como divulgaram o retrato, resolveram o delito de estelionato. O suspeito foi denunciado.

106a/ Como não se juntou aos grevistas, Carlo apresentou desculpas. A greve era geral.

106b/ Como não se juntou aos grevistas da empresa, Carlo apresentou desculpas. A greve era geral.

106c/ Como não se juntou aos grevistas, Carlo apresentou desculpas honestas. A greve era geral.

107a/ Quando Cássio visitou a favela, ele não gostou dos barracos. A higiene era inadequada

107b/ Quando Cássio visitou a favela da cidade, ele não gostou dos barracos. A higiene era inadequada.

107c/ Quando Cássio visitou a favela, ele não gostou dos barracos de taipa. A higiene era inadequada.

108a/ Como o avião fez barulho, ele prejudicou o ouvido. Teve que ir ao médico.

108b/ Como o avião fez barulho infernal, ele prejudicou o ouvido. Teve que ir ao médico.

108c/ Como o avião fez barulho, ele prejudicou o ouvido do passageiro. Teve que ir ao médico.

109a/ Como nós fizemos uma listagem, identificamos as pessoas. Tivemos nomes e endereços.

109b/ Como nós fizemos uma listagem de convidados, identificamos as pessoas. Tivemos nomes e endereços.

109c/ Como nós fizemos uma listagem, identificamos as pessoas presentes. Tivemos nomes e endereços.

110a/ Como não colocou o acento, a palavra não teve sentido. Corrigiu o erro então.
110b/ Como não colocou o acento apropriado, a palavra não teve sentido. Corrigiu o erro então.
110c/ Como não colocou o acento, a palavra não teve sentido correto. Corrigiu o erro então.

111a/ Quando chamaram o atleta, ela levantou a bandeira. Emocionou a torcida.
111b/ Quando chamaram o atleta brasileiro, ela levantou a bandeira. Emocionou a torcida.
111c/ Quando chamaram o atleta, ela levantou a bandeira do país. Emocionou a torcida.

112a/ Quando Duarte viu a aranha, ele pegou a escada. O animal subiu a parede.
112b/ Quando Duarte viu a aranha gigante, ele pegou a escada. O animal subiu a parede.
112c/ Quando Duarte viu a aranha, ele pegou a escada de madeira. O animal subiu a parede.

113a/ Como destruíram sua cabana, ela levou seus pertences. O pai a ajudou.
113b/ Como destruíram sua cabana de madeira, ela levou seus pertences. O pai a ajudou.
113c/ Como destruíram sua cabana, ela levou seus pertences pessoais. O pai a ajudou.

114a/ Como Mara comprou a vassoura, ela recebeu um recibo. Guardou no bolso.
114b/ Como Mara comprou a vassoura de piaçava, ela recebeu um recibo. Guardou no bolso.
114c/ Como Mara comprou a vassoura, ela recebeu um recibo de compra. Guardou no bolso.

115a/ Depois que Cícero teve sucesso, ele efetuou viagens. É um homem realizado.
115b/ Depois que Cícero teve sucesso financeiro, ele efetuou viagens. É um homem realizado.
115c/ Depois que Cícero teve sucesso, ele efetuou viagens de lazer. É um homem realizado.

116a/ Como eles subiram a ladeira, se expuseram a perigos. A pista era de barro.
116b/ Como eles subiram a ladeira da montanha, se expuseram a perigos. A pista era de barro.
116c/ Como eles subiram a ladeira, se expuseram a perigos de queda. A pista era de barro.

117a/ Depois que ouviram os disparos, eles chamaram reforço. Duas viaturas chegaram.
117b/ Depois que ouviram os disparos de fuzil, eles chamaram reforço. Duas viaturas chegaram.
117c/ Depois que ouviram os disparos, eles chamaram reforço policial. Duas viaturas chegaram.

118a/ Depois que consultou a poupança, ele imprimiu o extrato. Usou o caixa eletrônico.

118b/ Depois que consultou a poupança anual, ele imprimiu o extrato. Usou o caixa eletrônico.

118c/ Depois que consultou a poupança, ele imprimiu o extrato bancário. Usou o caixa eletrônico.

119a/ Quando Aura decorou a varanda, ela colocou banquetas. O espaço ficou agradável.

119b/ Quando Aura decorou a varanda da casa, ela colocou banquetas. O espaço ficou agradável.

119c/ Quando Aura decorou a varanda, ela colocou banquetas altas. O espaço ficou agradável.

120a/ Quando eles souberam das ofertas, compraram as bermudas. Fizeram um bom negócio.

120b/ Quando eles souberam das ofertas de desconto, compraram as bermudas. Fizeram um bom negócio.

120c/ Quando eles souberam das ofertas, compraram as bermudas masculinas. Fizeram um bom negócio.

121a/ Como não conseguiu a licença, não organizou o combate. Foi proibido.

121b/ Como não conseguiu a licença da prefeitura, não organizou o combate. Foi proibido.

121c/ Como não conseguiu a licença, não organizou o combate de galo. Foi proibido.

122a/ Quando nós vimos o feirante, ele carregava um pacote. Voltava da feira.

122b/ Quando nós vimos o feirante de peixe, ele carregava um pacote. Voltava da feira.

122c/ Quando nós vimos o feirante, ele carregava um pacote de frutas. Voltava da feira.

123a/ Depois que consultou as despesas, ele imprimiu o extrato. Usou o caixa eletrônico.

123b/ Depois que consultou as despesas pessoais, ele imprimiu o extrato. Usou o caixa eletrônico.

123c/ Depois que consultou as despesas, ele imprimiu o extrato bancário. Usou o caixa eletrônico.

124a/ Como processaram o cronista, ele viveu tormentos. O processo foi absolvido.

124b/ Como processaram o cronista de política, ele viveu tormentos. O processo foi absolvido.

124c/ Como processaram o cronista, ele viveu tormentos de injustiça. O processo foi absolvido.

125a/ Quando Bela escutou a amostra, ela não ouviu ruído. Fez uma coleta boa.

125b/ Quando Bela escutou a amostra da gravação, ela não ouviu ruído. Fez uma coleta boa.

125c/ Quando Bela escutou a amostra, ela não ouviu ruído sonoro. Fez uma coleta boa.

126a/ Quando o agente viu a escolta, ele adotou uma postura. Era o carro do governador.

126b/ Quando o agente viu a escolta policial, ele adotou uma postura. Era o carro do governador.

126c/ Quando o agente viu a escolta, ele adotou uma postura corporal. Era o carro do governador.

127a/ Depois que percebeu a laguna, ele alertou o comparsa. Não atravessaram a água.

127b/ Depois que percebeu a laguna dos Patos, ele alertou o comparsa. Não atravessaram a água.

127c/ Depois que percebeu a laguna, ele alertou o comparsa em fuga. Não atravessaram a água.

128a/ Assim que Roseane leu o recado, ela deu uma risada. A mãe ficou curiosa.

128b/ Assim que Roseane leu o recado da amiga, ela deu uma risada. A mãe ficou curiosa.

128c/ Assim que Roseane leu o recado, ela deu uma risada maligna. A mãe ficou curiosa.

129a/ Depois que consumiu a bebida, ele esqueceu sua bengala. Estava descontrolado.

129b/ Depois que consumiu a bebida alcoólica, ele esqueceu sua bengala. Estava descontrolado.

129c/ Depois que consumiu a bebida, ele esqueceu sua bengala de madeira. Estava descontrolado.

130a/ Como Nânci esqueceu a lancheira, ela não comeu banana. Avisou à mãe.

130b/ Como Nânci esqueceu a lancheira da escola, ela não comeu banana. Avisou à mãe.

130c/ Como Nânci esqueceu a lancheira, ela não comeu banana da terra. Avisou à mãe.

131a/ Como Rai gosta da Europa, ele visitou a Espanha. Ficou em um hotel lindo.

131b/ Como Rai gosta da Europa ocidental, ele visitou a Espanha. Ficou em um hotel lindo.

131c/ Como Rai gosta da Europa, ele visitou a Espanha do rei Filipe. Ficou em um hotel lindo.

132a/ Como Lara já usou o perfume, ela reconheceu o produto. Comprou outra marca.

132b/ Como Lara já usou o perfume desagradável, ela reconheceu o produto. Comprou outra marca.

132c/ Como Lara já usou o perfume, ela reconheceu o produto de má qualidade. Comprou outra marca.

133a/ Como renovou o banheiro, comprou uma privada. Ficou mais requintado.

133b/ Como renovou o banheiro da casa, comprou uma privada. Ficou mais requintado.

133c/ Como renovou o banheiro, comprou uma privada moderna. Ficou mais requintado.

134a/ Como visitou a Holanda, Nicole trouxe presentes. Comprou muitas coisas.

134b/ Como visitou a Holanda de Van Gogh, Nicole trouxe presentes. Comprou muitas coisas.

134c/ Como visitou a Holanda, Nicole trouxe presentes lindos. Comprou muitas coisas.

APENDIX II: Fillers (preenchedores)

1. Já que Jorge é responsável pelos seus comentários, ele não fez postagens ofensivas.
2. Como ele e o irmão ganharam na lotérica, compraram uma casa e um carro.
3. Quando viram o pescador chegando, lhe ajudaram a tirar o barco da água.
4. Como o bandido atirou várias vezes no policial, os disparos atingiram a viatura.
5. Assim que o suspeito de clonagem de cartão saiu de casa, ele foi preso pela polícia.
6. Como Neto quis se distanciar dos outros membros do comitê, ele saiu da reunião.
7. Já que o Grêmio não fez proposta aos jogadores, eles não deixaram o Flamengo.
8. Como o grupo chegou, o professor começou a discussão a respeito do evento.
9. Assim que Márcio percebeu a chegada do tubarão branco, ele saiu do mar correndo.
10. Já que não há água doce na região, eles estão intrigados com a presença dos jacarés.
11. Como os animais são de uma espécie muito mais agressiva, ficam nas gaiolas.
12. Desde que incluíram a prova didática no concurso, os candidatos ficaram felizes.
13. Quando o emissor de mensagem dá uma ordem, trata-se de frase imperativa.
14. Como o desembargador que destratou o garçom, levou lição de moral do cliente.
15. Já que o deputado sofre de problema psiquiátrico, renunciou ao mandato .
16. Como o final do ano se aproxima, a apresentadora comenta sobre preparativos.
17. Como o leão atacou a zebra, os visitantes de zoológico ficaram chocados.
18. Quando se trata da vida pessoal, o professor costuma ser bastante discreto.
19. Desde que o político deixou a prisão no início do mês, morou com a filha.
20. Como o artista quis deixar a vida mais feliz, resolveu aderir às redes sociais.
21. Como o adolescente americano ameaçou a irmã do amigo, ele foi preso por policiais.
22. Quando a mulher viu o tio agonizar na porta do hospital, ela se desesperou.
23. Como os pais esqueceram o bebê com aquecedor no quarto, ele passou mal.
24. Como a justiça obrigou o pai a pagar a pensão, ele foi depositar o dinheiro.
25. Desde que proibiram discussão de gênero nas escolas, teve paralisação no estado.
26. Como a cozinheira da escola deu almoço de graça para alunos, ela foi demitida.
27. Assim que ela vendeu a obra de arte, doou o valor da venda a um orfanato.
28. Já que Porta dos Fundos estará em São Paulo, estreará a peça de improviso.
29. Como o livro foi o mais buscado por alunos, ele ficou escasso nas livrarias.
30. Como flagraram a faxineira comendo doces, ela foi autuada por furto qualificado.
31. Como o escritor do livro foi o mais buscado por leitores, ele ficou famoso.
32. Quando o turista francês boiava na beira do mar, foi atacado por tubarão.

33. Desde que o parque construído para Olimpíada foi aberto, fui lá duas vezes.
34. Quando a artista famosa publicou fotos sem retoque, os seguidores curtiram.
35. Ainda que fosse o homem mais rico do país, ele não ganharia as eleições.
36. Como estamos a menos de uma semana de natal, corremos para fazer as compras.
37. Quando a artista famosa publicou fotos sem retoque, os seguidores curtiram.
38. Como o ladrão voltou à cena do crime, ele foi reconhecido por testemunhas.
39. Quando o rio Jacuípe transbordou, deixou mais de mil pessoas desabrigadas.
40. Como Paula se machucou ao cair do carro, permaneceu internada no hospital.
41. Primeiro campo de futebol iluminado por energia solar e cinética fica aqui.
42. Ronaldo vai construir estádio pequeno em bairro onde ficava sua antiga casa.
43. O cão com paralisia ganha cadeira de rodas e tratamento da veterinária.
44. A Rede Sustentabilidade denuncia ataque de madeireiros a indígenas no Brasil.
45. O conferencista afirma que ação pelo clima não exige fim do crescimento.
46. Os famosos expressam solidariedade ao músico nas redes sociais após crise.
47. Os mais importantes estilistas do mundo se reunirão no Rio de Janeiro este mês.
48. O prefeito caiu e fraturou a perna direita durante a festa de fim de ano.
49. O secretário de Direitos Humanos da prefeitura de Maceió chegou atrasado.
50. Samarco fecha acordo parcial para indenizar vítimas de barragem em Minas.
51. A Receita Federal investiga doações de empreiteiras à empresa do político.
52. As principais bolsas europeias fecharam em forte alta nesta quarta-feira.
53. Cientistas descobrem na Amazônia uma aranha brasileira capaz de voar.
54. João deixa o cargo na federação de atletismo por envolvimento em doping.
55. O Banco Central diz que sua missão no próximo ano é segurar a inflação.
56. Alunos de escolas ocupadas pedem doações para a ceia de Natal em Goiás.
57. Um paciente toca saxofone durante cirurgia no cérebro nos Estados Unidos.
58. Portugal quer liberdade de circulação e residência entre países lusófonos.
59. O fim do controle cambial na Argentina influenciará comércio com Brasil.
60. Um refugiado foi resgatado do mar após o naufrágio do seu barco ontem.
61. Um homem ferido foi ouvido pela polícia na madrugada desta quinta-feira.
62. Um jacaré é encontrado em recepção de fábrica de biscoitos em São Paulo.
63. Uma equipe da Defesa Civil foi chamada para capturar um jacaré em Maceió.
64. A Igreja Batista da cidade chamou hoje a atenção da mídia local e nacional.
65. Essa senhora percebe que o marido está alcoolizado e o expulsa da sua casa.

66. O vereador da cidade do meu colega argumentou que nunca traiu seu partido.
67. O artilheiro do time fala sobre lesão no joelho e prevê volta em sete meses.
68. A irmã do meu amigo curte praia com o noivo um dia antes do casamento.
69. Ele dá mais um passo na sua história esse ano com ajuda do melhor amigo.
70. A empresa instaurou um processo administrativo para investigar um gerente.
71. A agressão aos jovens aconteceu na noite de segunda feira na saída do estádio.
72. O menino negou ter participado diretamente da confusão que ocorreu ontem.
73. Os vereadores aumentam próprios salários na véspera do Natal em São Paulo.
74. O ministro da justiça determinou o corte dos pontos de trabalho dos grevistas.
75. A prefeitura de Rio de Janeiro convida moradores de rua para a ceia de Natal.
76. Valéria acredita que seu transtorno alimentar surgiu pela ausência de seu pai.
77. Meus amigos esperam que a festa deste ano seja melhor de que as anteriores.
78. Nós visitamos a ilha que prosperou com a descoberta de um tesouro sob a terra.
79. Ele diz que a influência humana permite a cães imitar expressões uns dos outros.
80. O zagueiro confessou que tinha nervos à flor de pele no início do último jogo.
81. Ela construiu barreiras na frente da casa. Os vizinhos irritados reclamaram.
82. Marcos adora comer comida caseira. Ele vai ao restaurante do bairro sempre.
83. Fred assistiu ao sorteio da Mega-Sena pela televisão. Ele pensou que ganharia.
84. A professora viajou para os Estados Unidos. Ela sempre quis visitar esse país.
85. Nicole se comporta de maneira bem gentil. Ela ajuda os amigos sempre.
86. O professor de física está sobrecarregado. A escola contratará um auxiliar.
87. A partida acabou com um empate sem gols. Os dois times se classificaram.
88. Renan resolveu os exercícios de matemática. Ele é um estudante brilhante.
89. Alice e Isabela fizeram intrigas. Elas passaram o dia inteiro fofocando.
90. O aluno mereceu os aplausos da plateia. Ele fez um discurso emocionante.
91. A proposta foi vetada pela maioria dos deputados. A população ficou feliz.
92. O turista foi obrigado a encurtar a estada no Recife. Tem uma emergência.
93. Adriano bebeu bastante na festa de aniversário. Ele não conseguir dirigir.
94. O músico contratou dois advogados para a defesa. Ele é acusado de crime.
95. Clara escreveu um romance que exigiu cuidados. Solicitou ajuda de escritores.
96. Camila batalhou muito para terminar o curso. A família não tenha dinheiro.
97. O surfista se esqueceu de levar a bermuda para a praia. Ele não pôde treinar.
98. Ele demostrou muita responsabilidade. Enviou uma mensagem de desculpas.

99. O dentista abrirá um consultório. Precisa de equipamentos odontológicos.
100. A avó foi para o parque sem a bengala. Ela teve muita dificuldade para andar.
101. O estudante foi expulso da universidade. Ela agrediu o professor de inglês.
102. O laboratório adquiriu uma cabina acústica. Teremos gravações de qualidade.
103. Lara sentiu saudades do irmão mais novo. Ela passou dois anos estudando fora.
104. O restaurante da escola solicitou bandejas. O número de aluno aumentou.
105. O governo fiscalizou as condições nos açougues. A medida foi necessária.
106. Os jogos olímpicos no Brasil foram um sucesso. A mídia estrangeira afirmou.
107. O prefeito proibiu ação de vendedores no parque. Policiais foram vistos no local.
108. O consumo de gordura oferece risco à saúde. O médico avisou os pacientes.
109. O limite de gastos deve ser respeitado. Os comitês de campanhas foram avisados.
110. A mãe foi flagrada agredindo o próprio filho. A polícia estadual divulgou o vídeo.
111. A mansão da cidade é magnificente. O autor do projeto é um arquiteto italiano.
112. Pedro viu a cobertura do desastre ambiental em Mariana. Foi ajudar as vítimas.
113. Berto revelou o segredo da família no tribunal. O pai tinha outra esposa.
114. Cael mereceu o respeito dos amigos. Ariscou a vida para salvar o animal ferido.
115. Lívia não subiu a montanha com a família. Ela sempre teve medo de altura.
116. O menino entrou em desespero para não ter que tomar vacina. A mãe o segurou.
117. Cientistas adotaram nova tecnologia pra capturar imagens raras. Usaram drones.
118. O corista não finalizou sua reserva de hotel. Ele teve problema de hospedagem.
119. A mídia revelou o dono do carro de luxo. Ele é herdeiro de um milionário inglês.
120. Estudantes ocuparam o Núcleo de Educação em Curitiba. A polícia foi chamada.

APENDIX III: Written informed consent form

Termo de Consentimento Livre e Esclarecido (T.C.L.E.)

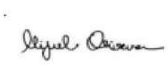
(Em 2 vias, firmado por cada participante-voluntári(o,a) da pesquisa e pelo responsável)

Eu ...., tendo sido convidad(o,a) a participar como voluntári(o,a) do estudo **Correlatos eletrofisiológicos do processamento de fronteiras prosódicas no português brasileiro**, recebi de Oyedeji Musiliyu, estudante de doutorado do Programa de Pós-Graduação em Letras e Linguística, sob a orientação do Prof. Dr. Miguel Oliveira Jr – Faculdade de Letras – UFAL, responsável por sua execução, as seguintes informações que me fizeram entender sem dificuldades e sem dúvidas os seguintes aspectos:

- Que o estudo se destina a estudar, por meio de experimento de percepção, os correlatos eletrofisiológicos relacionados a fronteiras prosódicas no português brasileiro.
- Que a importância deste estudo é a de contribuir para explicar o processamento eletrofisiológico da percepção da fala no nível da estrutura hierárquica prosódica.
- Que os resultados que se desejam alcançar são os seguintes: i) confirmação, por meio de análises acústicas, de pistas prosódicas que sinalizam fronteiras prosódicas nos níveis do sintagma entonacional e do enunciado fonológico em enunciados elaborados com um padrão sintático e prosódico particular; e ii) observação de características do CPS, componente de Potenciais Relacionados a Eventos, em termos de tempo, amplitude e distribuição do escalpe nas fronteiras prosódicas dos dois diferentes níveis mais altos da hierarquia prosódica, de acordo com os preceitos da Fonologia Prosódica.
- Que esse estudo começará em abril de 2016 e terminará em março de 2018.
- Que o estudo será feito mediante a realização das seguintes etapas: (i) elaborar enunciados com padrão sintático e prosódico particular de três tipos: A, B (estímulos experimentais; 30 enunciados de cada tipo) e F (estímulos preenchedores; 120 enunciados); (ii) realizar a gravação dos enunciados por um falante adulto, nativo do português brasileiro; (iii) realizar as análises acústicas para confirmar as diferentes fronteiras prosódicas nos enunciados; (iv) Obter o registro eletrofisiológico das diferentes fronteiras prosódicas, mediante o uso do Geodesic EEG System 400 (*Electrical Geodesics, Inc*) de 256 eletrodos, disponível no Laboratório de Psicolinguística da Universidade Federal de Alagoas. O sistema em questão utiliza touca patenteada que possui eletrodos em número suficiente para abranger áreas da cabeça comumente monitoradas em estudos de processamento da linguagem. Os estímulos serão executados via fones de ouvido (SE earphone) de alta sensibilidade (Shure SE535); (v) Para a tarefa comportamental, que acontecerá simultaneamente à coleta de dados com EEG, será solicitado aos participantes do experimento que segmentem, pressionando uma tecla em

uma caixa de resposta (Response Pad RB-740, Cedrus Inc.), os enunciados que ouvem como estímulo. Os estímulos serão apresentados de uma maneira semialeatória, assegurando a generalidade dos resultados. Dados comportamentais sobre acurácia e tempo de reposta serão coletados através da utilização do software E-Prime (Psychology Software Tools, Inc.).

- Que eu participarei das seguintes etapas: (iv) Obtenção de registro eletrofisiológico das diferentes fronteiras prosódicas; e (v) a tarefa comportamental.
- Que os incômodos e possíveis riscos à minha saúde física e mental são: insignificantes, com possíveis incômodos comumente associados ao ambiente experimental do laboratório e a repetição de estímulos sonoros.
- Que os benefícios que deverei esperar com a minha participação, mesmo que não diretamente são: (i) contribuir ao conhecimento científico na área de Neurolinguística e Ciência da Linguagem com estudos baseados no método de potenciais relacionados a eventos no português brasileiro; (ii) disponibilizar, para as futuras pesquisas, informações valiosas no que diz respeito a processamento cognitivo da prosódia no português brasileiro.
- Que, sempre que desejar, serão fornecidos esclarecimentos sobre cada uma das etapas do estudo.
- Que, a qualquer momento, eu poderei recusar a continuar participando do estudo e, também, que eu poderei retirar este meu consentimento, sem que isso me traga qualquer penalidade ou prejuízo.

- Que as informações conseguidas através da minha participação não permitirão a identificação da minha pessoa, exceto aos responsáveis pelo estudo, e que a divulgação das mencionadas informações só será feita entre os profissionais estudiosos do assunto.
- Que não haverá despesas relativas à minha participação nesta pesquisa.
- Que eu serei indenizado por qualquer despesa que venha a ter com a participação na pesquisa.
- Que eu receberei uma via do Termo de Consentimento Livre e Esclarecido.
- Finalmente, tendo eu compreendido perfeitamente tudo o que me foi informado sobre a minha participação no mencionado estudo e estando consciente dos meus direitos, das minhas responsabilidades, dos riscos e dos benefícios que a minha participação implicam, concordo em dele participar e para isso eu DOU O MEU CONSENTIMENTO SEM QUE PARA ISSO EU TENHA SIDO FORÇADO OU OBRIGADO.

Endereço d(o,a) participante-voluntári(o,a)
Domicílio: (rua, praça, conjunto):
Bloco: /Nº: /Complemento:
Bairro: /CEP/Cidade: /Telefone:
Ponto de referência:

Contato de urgência: Sr(a).
Domicílio: (rua, praça, conjunto)
Bloco: /Nº: /Complemento:
Bairro: /CEP/Cidade: /Telefone:
Ponto de referência:

Endereço d(os,as) responsáve(l,is) pela pesquisa (OBRIGATÓRIO):
Instituição: Programa de Pós-Graduação em Letras e Linguística - FALE
Endereço: Av. Lourival Melo Mota, S/N, Campus A.C. Simões
Bloco: /Nº: /Complemento:
Bairro: /CEP/Cidade: Tabuleiro do Martins – CEP 57072-970 – Maceió - AL
Telefones p/contato: (82) 3214-1463, 3214-1640

ATENÇÃO: Para informar ocorrências irregulares ou danosas durante a sua participação no estudo, dirija-se ao:
Comitê de Ética em Pesquisa da Universidade Federal de Alagoas
Prédio da Reitoria, 1º Andar, Campus A. C. Simões, Cidade Universitária.
Telefone: 3214-1041

Maceió, 17 de fevereiro de 2016

	Prof. Dr. Miguel Oliveira Jr Oyedeji Musiliyu
Assinatura ou impressão datiloscópica d(o,a) voluntári(o,a) ou responsável legal e rubricar as demais folhas	Nome e Assinatura do(s) responsável(eis) pelo estudo (Rubricar as demais páginas)

APENDIX IV: Brazilian Portuguese version of the Edinburgh Handedness Inventory

Inventário De Dominância Manual De Edimburgo

Você tem alguma tendência do uso da mão esquerda?

Sim   Não

Indique, por favor, suas preferências no uso de mãos nas atividades abaixo *colocando* + na coluna adequada. Situações em que a preferência é tão forte que você não usaria outra mão, a menos que fosse obrigado (a), *coloque* ++. Em qualquer caso, se você for realmente indiferente, *coloque* + em ambas as colunas.

Algumas das atividades requerem ambas as mãos. Nesses casos, a parte da tarefa ou do objeto em que a preferência de mão é precisa está indicada entre parênteses.

		Direita	Esquerda
1	Escrever		
2	Desenhar		
3	Arremessar		
4	Uma tesoura		
5	Um pente		
6	Uma escova de dente		
7	Uma faca (sem garfo)		
8	Uma colher		
9	Um martelo		
10	Uma chave de fenda		
11	Uma raquete de tênis		
12	Uma faca (com garfo)		
13	Um bastão de críquete (canto inferior)		
14	Um bastão de golfe (canto inferior)		
15	Uma vassoura (canto superior)		
16	Um gadanho (canto superior)		
17	Caixa de fósforos (um fósforo)		
18	Abrir uma caixa (a tampa)		
19	Dar cartas em uma jogada (a carta dada)		
20	Por linha na agulha (agulha ou linha, o que estiver sendo movido)		
21	Qual pé você prefere usar para chutar?		
22	Qual olho você prefere quando usa um só olho?		

Informação sobre a língua

Sexo .... Idade ....

Local de nascimento ....

Anos de escolaridade (12 para ensino médio completo, mais um para cada ano além) .....

Mão dominante.................................... Primeira língua aprendida ....

Outras línguas faladas fluentemente ....

Idade da aprendizagem da primeira .... Segunda ....
Outras ....

Línguas dos pais faladas e idade de aquisição:
Mãe ....
Pai ....
A principal (se for declarado) ....

Você tem alguns problemas com o ouvido, a leitura ou fala? ....
Se for sim, por favor explique ....

Formulário de informações pessoais

Nome: ....

Data de nascimento: ....

Endereço:
....
....
....

Telefone: ....

Raça/Cor:...

Por favor, preenche o próximo formulário. Todas as respostas são confidenciais.

Você pode requerer que este formulário seja acessível apenas ao pesquisador do projeto. Se você não requerer isso, o formulário será acessível ao assistente de pesquisador.

Para requerer que o formulário seja acessível apenas ao pesquisador, indique aqui:..........

Questões: por favor, marque resposta apropriada. Por favor, descreva ou explique qualquer resposta "sim" no verso deste formulário.

	Sim	Não
1. Você toma alguma medicação?	( )	( )
2. Você toma alguns medicamentos de venda livre?	( )	( )
3. Você usa algumas drogas recreativas ou álcool?	( )	( )
4. Você está recebendo algum tratamento médico?	( )	( )
5. Você tem algumas alergias?	( )	( )
6. Sua visão corrigida está significativamente menor do que 20/20?	( )	( )
7. Você já teve um ferimento na cabeça ou ficou inconsciente?	( )	( )
8. Você já teve uma convulsão?	( )	( )
9. Você já teve um distúrbio neurológico ou psicológico?	( )	( )
10. Você já participou de outros estudos científicos?	( )	( )

Por favor, responda o resto das questões no espaço fornecido e no verso deste formulário, se for necessário.

11. Qual o seu nível de escolaridade?

....

12. Você é destro ou canhoto?

....

13. Você tem parentes consanguíneos que são canhotos?

....

14. Você algumas outras condições ou circunstâncias que gostaria de nos informar?

....

Nome: ....

Data: ....

ANEX I: Channel location file for the 256-channels HydroCel Geodesic Sensor Net (txt. Format)

FidNz 0.00000 10.56381 -2.05108
FidT9 -7.82694 0.45386 -3.76056
FidT10 7.82694 0.45386 -3.76056
E1 6.96223 5.38242 -2.19061
F8 6.48414 6.40424 -0.14004
E3 5.69945 7.20796 1.79088
E4 4.81093 7.77321 3.65006
F2 3.61962 7.47782 5.50947
E6 2.25278 6.46157 6.96317
E7 1.18879 5.21755 8.13378
E8 0.00000 3.59608 8.75111
E9 -1.15339 1.51369 9.19904
AF8 5.94022 7.38337 -1.51513
E11 5.07624 8.37264 0.40595
AF4 3.87946 9.03611 2.51559
E13 2.60756 8.97868 4.39107
E14 1.23344 8.11574 6.06161
FCz 0.00000 6.81181 7.28186
E16 -1.18879 5.21755 8.13378
E17 -2.29559 2.91372 8.55810
Fp2 4.06489 9.40559 -0.89098
E19 2.86784 10.01456 0.85212
E20 1.42153 10.06322 2.84803
Fz 0.00000 9.40339 4.65829
E22 -1.23344 8.11574 6.06161
E23 -2.25278 6.46157 6.96317
FC1 -3.34467 4.40891 7.67253
E25 1.39547 10.65281 -0.61138
Afz 0.00000 10.68996 1.00542
E27 -1.42153 10.06322 2.84803
E28 -2.60756 8.97868 4.39107
F1 -3.61962 7.47782 5.50947
E30 -4.49828 5.59395 6.28801
E31 0.00000 10.56381 -2.05108
E32 -1.39547 10.65281 -0.61138
E33 -2.86784 10.01456 0.85212
AF3 -3.87946 9.03611 2.51559
E35 -4.81093 7.77321 3.65006
F3 -5.10466 6.41586 4.77815
Fp1 -4.06489 9.40559 -0.89098
E38 -5.07624 8.37264 0.40595
E39 -5.69945 7.20796 1.79088
E40 -6.16984 6.11292 3.29612
E41 -6.01447 4.93908 4.85771
FC3 -5.33943 3.80220 6.32664
E43 -4.64127 2.57224 7.50868
C1 -3.53746 1.07133 8.47419
E45 -1.99458 -0.60998 9.28870
AF7 -5.94022 7.38337 -1.51513
F7 -6.48414 6.40424 -0.14004
F5 -6.97545 5.35131 1.30741
FC5 -7.10064 4.23342 2.91874
E50 -6.86564 3.16240 4.76800
E51 -6.11380 1.94213 6.23844
E52 -5.31389 0.60081 7.48811
E53 -3.72368 -1.14573 8.58697
E54 -6.96223 5.38242 -2.19061
E55 -7.31613 4.37155 -0.61128
E56 -7.66385 3.29619 1.04415
E57 -7.62423 2.30205 2.81799
E58 -7.36570 1.34368 4.60382
C3 -6.70292 0.06004 6.23992
E60 -5.40372 -1.61247 7.47343
E61 -7.54098 3.05323 -2.51935
FT7 -7.77059 2.06323 -0.80729
E63 -7.96921 1.20744 0.97332
C5 -8.06621 0.40109 2.78565
E65 -7.60767 -0.56840 4.59939
CP3 -6.81554 -1.94522 5.93053
Ft9 -7.69315 1.74041 -4.18153
T9 -7.74468 1.05291 -2.47059
T7 -7.93758 0.07220 -0.96992
E70 -7.98893 -0.75212 0.84194
E71 -8.05947 -1.50296 2.76753
E72 -7.56445 -2.31141 4.30327
E73 -7.52646 0.73096 -5.96025
E74 -7.76752 -1.84131 -0.92719
E75 -7.79279 -2.73175 1.10033
Cp5 -7.46191 -3.49308 2.95937
E77 -6.86934 -3.79448 4.89401
E78 -5.65276 -3.84604 6.52108
CP1 -4.12465 -3.54800 7.95405
E80 -2.23647 -2.95809 8.92461
Cpz 0.00000 -1.93834 9.45867
E82 -7.12806 -0.49186 -7.34929
E83 -7.37920 -3.49709 -2.18347
TP7 -7.52183 -3.70044 -0.51432

E85 -7.15214 -4.71132 1.51762
P5 -6.48817 -5.15829 3.47294
P3 -5.53051 -5.46184 5.50189
P1 -4.03809 -5.23807 7.04455
E89 -2.29514 -4.87829 8.27223
E90 0.00000 -3.74195 9.02791
E91 -6.82585 -1.86426 -8.69399
E92 -6.74047 -2.84840 -6.74712
E93 -6.78379 -4.01784 -5.01755
TP9 -7.03346 -4.45090 -3.54895
E95 -6.99052 -5.01694 -1.88810
P7 -6.67571 -5.73608 0.10234
Po7 -5.96851 -6.52864 2.03293
E98 -5.10822 -6.74936 3.92134
E99 -3.75216 -6.67734 5.63719
E100 -2.14874 -6.29190 7.11453
Pz 0.00000 -7.15042 6.95434
E102 -6.36989 -3.82470 -8.20622
E103 -6.24349 -4.62250 -6.49623
E104 -6.09726 -5.61090 -4.67894
E105 -6.31441 -6.01299 -3.25921
P9 -5.98418 -6.74733 -1.40314
E107 -5.23709 -7.57398 0.46627
E108 -4.29098 -8.11323 2.38442
PO3 -3.24277 -8.15293 4.22025
E110 -1.73181 -7.63850 5.69360
E111 -5.63580 -5.80367 -7.74857
E112 -5.38718 -6.45180 -6.16689
E113 -5.08285 -7.32643 -4.32109

E114 -5.27282 -7.46584 -2.87485
E115 -4.13620 -8.61230 -1.04503
O1 -3.13323 -9.13629 0.81878
E117 -1.94503 -9.23415 2.62135
E118 -1.09312 -8.74110 4.13810
Poz 0.00000 -8.09146 5.34087
E120 -4.70608 -7.21970 -7.52955
E121 -4.20415 -7.81153 -5.84368
E122 -3.62234 -8.59338 -4.04243
E123 -3.02717 -9.45363 -1.95941
E124 -2.20152 -9.70916 -0.63755
E125 -1.01682 -9.71656 0.95467
Oz 0.00000 -9.23206 2.54671
E127 1.09312 -8.74110 4.13810
E128 1.73181 -7.63850 5.69360
E129 2.14874 -6.29190 7.11453
E130 2.29514 -4.87829 8.27223
E131 2.23647 -2.95809 8.92461
E132 1.99458 -0.60998 9.28870
E133 -3.45625 -8.57317 -6.82654
E134 -2.71528 -8.94646 -5.55376
E135 -2.03205 -9.56166 -3.44989
E136 -0.91885 -9.62744 -2.21054
E137 0.00000 -9.58535 -0.88629
E138 1.01682 -9.71656 0.95467
E139 1.94503 -9.23415 2.62135
PO4 3.24277 -8.15293 4.22025
E141 3.75216 -6.67734 5.63719
P2 4.03809 -5.23807 7.04455

Cp2 4.12465 -3.54800 7.95405
E144 3.72368 -1.14573 8.58697
E145 -1.88533 -9.22031 -6.79889
E146 -1.06111 -9.53369 -5.45325
E147 0.00000 -9.48329 -3.84204
E148 0.91885 -9.62744 -2.21054
E149 2.20152 -9.70916 -0.63755
O2 3.13323 -9.13629 0.81878
E151 4.29098 -8.11323 2.38442
E152 5.10822 -6.74936 3.92134
P4 5.53051 -5.46184 5.50189
E154 5.65276 -3.84604 6.52108
E155 5.40372 -1.61247 7.47343
E156 1.06111 -9.53369 -5.45325
E157 2.03205 -9.56166 -3.44989
E158 3.02717 -9.45363 -1.95941
E159 4.13620 -8.61230 -1.04503
E160 5.23709 -7.57398 0.46627
PO8 5.96851 -6.52864 2.03293
P6 6.48817 -5.15829 3.47294
E163 6.86934 -3.79448 4.89401
CP4 6.81554 -1.94522 5.93053
E165 1.88533 -9.22031 -6.79889
E166 2.71528 -8.94646 -5.55376
E167 3.62234 -8.59338 -4.04243
E168 5.27282 -7.46584 -2.87485
P10 5.98418 -6.74733 -1.40314
P8 6.67571 -5.73608 0.10234
E171 7.15214 -4.71132 1.51762

CP6 7.46191 -3.49308 2.95937
E173 7.56445 -2.31141 4.30327
E174 3.45625 -8.57317 -6.82654
E175 4.20415 -7.81153 -5.84368
E176 5.08285 -7.32643 -4.32109
E177 6.31441 -6.01299 -3.25921
E178 6.99052 -5.01694 -1.88810
TP8 7.52183 -3.70044 -0.51432
E180 7.79279 -2.73175 1.10033
E181 8.05947 -1.50296 2.76753
E182 7.60767 -0.56840 4.59939
C4 6.70292 0.06004 6.23992
E184 5.31389 0.60081 7.48811
C2 3.53746 1.07133 8.47419
E186 1.15339 1.51369 9.19904
E187 4.70608 -7.21970 -7.52955
E188 5.38718 -6.45180 -6.16689
E189 6.09726 -5.61090 -4.67894
TP10 7.03346 -4.45090 -3.54895
E191 7.37920 -3.49709 -2.18347
E192 7.76752 -1.84131 -0.92719
E193 7.98893 -0.75212 0.84194
C6 8.06621 0.40109 2.78565
E195 7.36570 1.34368 4.60382
E196 6.11380 1.94213 6.23844
E197 4.64127 2.57224 7.50868
E198 2.29559 2.91372 8.55810
E199 5.63580 -5.80367 -7.74857
E200 6.24349 -4.62250 -6.49623
E201 6.78379 -4.01784 -5.01755
T8 7.93758 0.07220 -0.96992
E203 7.96921 1.20744 0.97332
E204 7.62423 2.30205 2.81799
E205 6.86564 3.16240 4.76800
FC4 5.33943 3.80220 6.32664
FC2 3.34467 4.40891 7.67253
E208 6.36989 -3.82470 -8.20622
E209 6.74047 -2.84840 -6.74712
T10 7.74468 1.05291 -2.47059
FT8 7.77059 2.06323 -0.80729
E212 7.66385 3.29619 1.04415
FC6 7.10064 4.23342 2.91874
F214 6.01447 4.93908 4.85771
E215 4.49828 5.59395 6.28801
E216 6.82585 -1.86426 -8.69399
E217 7.12806 -0.49186 -7.34929
E218 7.52646 0.73096 -5.96025
Ft10 7.69315 1.74041 -4.18153
E220 7.54098 3.05323 -2.51935
E221 7.31613 4.37155 -0.61128
F6 6.97545 5.35131 1.30741
E223 6.16984 6.11292 3.29612
F4 5.10466 6.41586 4.77815
E225 7.62652 3.24782 -4.40493
F10 7.24346 4.80120 -4.77214
E227 7.55603 2.52648 -6.26962
E228 7.38028 1.35743 -7.84943
E229 6.86103 -0.14155 -9.14913
E230 6.74159 5.99080 -5.83258
E231 7.22458 4.14855 -6.88918
E232 7.31422 3.19647 -8.44268
E233 7.09051 1.66694 -9.77213
E234 5.88750 7.22674 -6.54736
E235 6.65934 5.64059 -7.65729
E236 6.75138 4.62427 -9.03070
E237 6.58044 3.33743 -10.39707
E238 4.69146 8.22723 -6.78260
E239 5.81346 6.42065 -8.65026
E240 6.04363 5.37051 -9.81363
E241 -4.69146 8.22723 -6.78260
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E243 -6.04363 5.37051 -9.81363
E244 -5.88750 7.22674 -6.54736
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E246 -6.75138 4.62427 -9.03070
E247 -6.58044 3.33743 -10.39707
E248 -6.74159 5.99080 -5.83258
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E251 -7.09051 1.66694 -9.77213
F9 -7.24346 4.80120 -4.77214
E253 -7.62652 3.24782 -4.40493
E254 -7.55603 2.52648 -6.26962
E255 -7.38028 1.35743 -7.84943
E256 -6.86103 -0.14155 -9.14913
Cz 0.00000 0.00000 9.68308