How prominent is L2 stress?
A perceptual investigation on the influence of (non) predominant stress position in languages of distinct metrical systems

Master's thesis

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Abstract

This study explores the effects of word stress prominence on native speakers' word perception in Brazilian Portuguese (BP). Words were realized by either native (L1) BP speakers or by non-native (L2) speakers who speak Dutch as their native language. BP and Dutch belong to different metrical systems. In both languages, stress has a distinctive function; i.e., words can be differentiated by the position of the stressed syllable (e.g.: in Dutch, VOORnaam "first name" and voorNAAM "respectable"). However, Dutch has a more varied distribution of stress patterns, whereas BP, on the other hand, has a predominantly prefinal stressed position. Both in Dutch and in BP suprasegmental information is the only cue in the perception of word stress. Yet, BP listeners are hypothesized to rely more on the expected default position for stress perception than on suprasegmental information. Presumably, if a language has stress patterns more evenly distributed across a word's syllables, then *correct* stress realization is perceptually more prominent than in languages where stress is almost always invariably at the same position.

This hypothesis was tested in a spoken word-recognition experiment. In languages in which stress has a distinctive function, words that are *incorrectly* stressed are recognized relatively slowly. Stress misplacement can even be slower recognized when produced by an L2 learner, because it can be reinforced by differences in segmental realization. Accordingly, it was investigated how native speakers of BP perceived correct stress and stress mismatches produced by an L1 BP and by an L1 Dutch (L2 BP) speaker. No significant difference was found concerning response times between L1 and L2 stimuli, but there was a main effect of item types for final-lexical stress incorrectly produced on medial position. This result was further reinforced by the error analysis, in which final-lexical stress incorrectly produced on medial position by the L2 BP were significantly slower recognized than the L1 BP counterpart. Not surprisingly, participants found it overall more difficult to recognize words produced by the Dutch L2 BP speaker. The results of the error analysis showed that when segmental and suprasegmental cues deviate from the native listener's prototypes, it is most detrimental to word recognition. Overall, the results suggest that prosodic acoustic cues in BP and in Dutch are as perceptually prominent. Also, prosodic cues are key for word recognition to BP listeners; yet, they are still biased by the default-penultimate position for stress perception.

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Chapter 1

1.1 General introduction

The present study aims at comparing the perception of word stress prominence between languages that belong to different metrical systems. More precisely, how stress prominence is perceived by native speakers of a source language when stimulus words are produced by a second language learner (L2). The source language in question here is Brazilian Portuguese (L1 BP). Auditory stimuli were produced by a Dutch speaker of BP (L2 BP) as a second language, as well as by a native speaker of BP.

The motivation for this investigation comes from a study by Dogil & Williams (1999), who compared the acoustic phonetic prominence of languages with distinct metrical systems: German and Polish. Word stress in German has a contrastive function; i.e., words can be distinguished by the position of the stressed syllable. Also, in German stress can be largely predicted by weight-sensitive phonological rules, in which stress can fall within the three-syllable window – antepenultimate (initial), penultimate (medial or prefinal) and final syllables; i.e., in one of the last three syllables in a right-to-left fashion – without a unique prevalent syllable location. In contrast, Polish is a weight-insensitive language with a fixed position for primary stress: the penultimate syllable. As a result, stress has a culminative function, and words are never distinguished by the position of the stressed syllable.

In an acoustic investigation involving German and Polish, Dogil & Williams showed that there is a clear difference in how primary stress is acoustically realized. In German, duration has proved to be a robust correlate of word stress; duration of the stressed syllable becomes even more prominent given the reduction version of the unstressed counterpart. In contrast, Polish primary stress does not manifest itself by means of longer duration, as unstressed syllables are not reduced. Therefore, word stress in Polish is not marked by any prominent acoustic correlate and therefore is said to have a weak acoustic phonetic prominence. Accordingly, Dogil and Williams argue that weight-sensitive languages have stress more forcefully realized than weight-insensitive ones. However, their results cast doubt to whether stress in weight-sensitive languages is acoustically more prominent than in weight-insensitive languages, since comparison has just been made to a language in which stress is not contrastive; that is, stress is not relevant to lexical identification.

In the present study, we investigate similar acoustic differences produced by Dutch and by BP speakers of BP, and how stress prominence is therefore perceived by native speakers of BP. In BP and in Dutch, stress is a contrastive phenomenon; i.e., words can be distinguished by the stress location (e.g., in BP *FÁbrica* “factory” vs. *faBRIca* 3rd person sig. present verb “manufacture”).[1] However, in terms of stress distribution, these languages have distinct ways of realizing stress, which may have

[1] Capital syllables indicate the main stressed syllable.

consequences in the production and perception of word stress. Such as German, Dutch has been classified as a weight-sensitive language in that stress position is highly dependent on the heavy syllable. Dutch prominence of stressed syllables is marked by longer duration, which can also be opposed by a reduced unstressed counterpart. In BP, on the other hand, although duration is the acoustic correlate par excellence, unstressed syllables are not reduced. Besides this, BP weight-insensitive nature brings about a fixed stressed position: i.e., predominantly prefinal. Thus the question that arises is whether BP can be assumed to have a weak acoustic stress prominence, such as Polish, since hardly ever a BP speaker has to stress another syllable than that of the penultimate position.

Van Heuven (personal communication) posits that languages that do not favour a unique syllable to mark word stress, as a function of syllable weight, may resort to prosodic cues to a great extent. Similar do German, Dutch is such a language. Van Heuven & Hagman (1988) showed that Dutch lacks a consistent stress position, in that stress is therefore more equally distributed among the three-syllable window. Accordingly, if the location of main stress is more evenly distributed over a word's syllables, it can function as an important source of word recognition for L1 Dutch. However, our hypothesis is that prominence of acoustic correlates of stress only becomes relevant when suprasegmental cues outweigh segmental cues to stress in lexical recognition. Despite the fact that in Dutch there is an alternation between full stressed and reduced unstressed vowels, contrary to English, experiments have shown that vowel reduction does not work as a segmental cue to stress (Cutler 1986; Kager 1989; Koster & Cutler 1997; Cutler & Van Donselaar 2001;Cooper et al. 2002).

Another important aspect to be considered in the present thesis is whether a prevalent stress location may bias BP listeners in the perception of stressed patterns. Production experiments have shown that BP speakers are biased by the default penultimate pattern in stress production in a L2 (Post da Silveira 2012; 2013). Results showed that not only greater number of correct responses were associated to the penultimate position, but also greater number of errors were produced in the same position. Thus the question that arises is whether the penultimate pattern may also bias BP listeners in the perception of stressed syllables. Our hypothesis is that since penultimate stress is the most expected one, it should also be the one most recognized. Yet, given the contrastive function of word stress in BP, we also assume that words realized with stress on a wrong syllable may cause delay in word recognition. And mis-stressed words produced by the Dutch L2 BP can have a special negative effect in word recognition (i.e., words can be even significantly slowly recognized) to BP listeners when wrong prosodic information is realized together with segmental differences. (Van Heuven 1988, 2008). In addition, a delay can be even more detrimental to word recognition when stress is wrongly produced on medial position, since speakers may think that they are listening to a word with penultimate stress.

Stress has been proved to play an important role in speech intelligibility. The literature already presents a wide range of evidence that prosodic cues, together with segmental information, accelerate the process of word identification in an L1 (Van Heuven 1988, 2008). By the same token, words that are mis-stressed were shown to result in delayed lexical identification (Van Heuven 1985). However, as of yet it is unknown the extent to which word recognition can be affected (inhibited) when we consider a second language stress production being perceived by native speakers of a source language, mainly when languages with different metrical systems are involved.

A way to test whether Dutch and BP acoustic realizations of stress differ from each other is by conducting a perception experiment in which BP stimulus words are produced with correct and wrong stress positions by L1 BP and Dutch L2 BP speakers. Our expectation is that mis-stressed words produced by the Dutch L2 BP will have a special negative effect (i.e., L2 BP words can be slower recognized) on word recognition to BP listeners - as a consequence of transfer from the Dutch L1 phonetic prominence (Rasier & Hiligsmann 2007), as well as because of segmental differences - than those produced by the L1 BP native speaker. Accordingly, the effect of incorrect stress should be more inhibitory to BP listeners when produced by the non-native speaker, as this may deviate from the BP listener's prototypes. As for the perception of the L1 BP incorrect stress, this should inhibit stress to a lesser extent, given the effect of the assumed weak phonetic implementation. We then expect that the acoustic cues produced by L1 BP are weaker than that produced by the Dutch L2 BP. As for the perception of correct stress, it is possible that the L2 BP stress realization activate lexical identification faster. This is due to the fact that both, BP and Dutch, employ duration as a robust cue for production and perception of stressed syllables. Thus if Dutch correlates of stress are more prominent than those of BP, it is possible that the Dutch production of the BP stress correct stimuli be faster recognized by BP listeners.

This thesis is organized as follows. In chapter 2(2.1), we give a brief description of the phonology of word stress, and the extent to which languages that belong to different metrical systems differ from each other. In the same section, we also describe how stress can be phonetically realized in the acoustic domain. Section 2.2 is concerned with the background literature, in which we start by presenting Dogil and Williams's (1999) investigation of the phonetic realization of German and Polish word stress. Chapter 3 focuses on how word stress is acoustically realized in Dutch and in BP. Then, by means of statistical distribution, we show the percentage of word stress patterns per syllable in Dutch and in BP, followed by our assumption of how different ways of distributing stress patterns may effect realization and consequently stress perception in related languages.

Chapter 4 concentrates on the description of experiments, mainly in Dutch and in BP, regarding the role of stress in lexical identification. This will be done by comparing related languages in how they differ in the use of stress cues, in both segmental and prosodic domains. In chapter 5 we investigate the perception of word recognition when BP stimulus words are produced by Dutch and BP speakers, in correct and incorrect syllable positions, followed by the results and discussion. Finally, this study is concluded with chapter 6, where we summarize our findings with a discussion, suggestions for future research and a conclusion.

Chapter 2 – Metrical systems and their relation to acoustic stress prominence

2.1 Phonological and phonetic prominence of stressed syllables

Stress can be defined as a linguistic property that indicates which syllable in a word is the most prominent one. Phonological prominence of stress, among other theories of word stress, has been studied by means of metrical systems (Liberman & Prince 1977; Hayes 1993). Metrical phonology has been usually represented by means of strong and weak relationships between stressed and unstressed syllables, either in a tree structure (Kiparsky 1979) or a in a metrical grid (Selkirk 1984). The similarity between these theories is that phonological stress prominence can be accounted for by the temporal duration of the syllable's segments (Sluijter 1995).

Natural languages have different ways of realizing stress prominence, both phonologically and phonetically (Van der Hulst 1999; Dogil & Williams 1999). In phonological terms, stress has *demarcative* and *culminative* functions. These terms have been used to refer to whether languages differ regarding the (non)mobility of the stressed syllable and its role when conveying a message. A demarcative function, for example, relates to languages with fixed stress. In languages as Polish and Hungarian, the most prominent syllable falls on one unique position: the penultimate syllable in Polish and the first syllable in Hungary, where the location of these languages' main stress have the word edge as reference (Trubetzkoy 1939; Van der Hulst 1999). Thus, word boundary can be exactly detected by the position of the stressed syllable. When stress has a culminative (also called distinctive or contrastive) function, one syllable is the most prominent within the word domain. Stress indicates the number of words in strings of speech, and it does not necessarily make reference to word boundaries.

Furthermore, stress can also, to some extent, be predicted by *weight-sensitive* rules. This term has been used to refer to stress rules that are sensitive to syllable structure. Although these rules are highly language specific, the common agreement that makes a syllable heavy, or stress-attracting, are long vowels and closed syllables, in contrast to a light syllable, which does not have these properties (Van der Hulst 1999). In this manner, stress in English and in Dutch is usually conditioned to syllable weight. In English, for example, heavy syllables most often stand out from their unstressed counterparts. Stressed syllables are always comprised of a long vowel as in the penultimate syllable of *aREna* /əˈriːnə/, or a syllable closed by a consonant, as *aGENda*. In Dutch, only closed syllables are taken as heavy, as in *plaCENta* "placenta" and *baLANS* "balance" (Trommelen & Zonneveld 1999; Kager 1989). In weight-insensitive languages stressed syllables are not conditioned by syllable weight. Polish is an example of a language that is not weight dependent. Conversely, penultimate syllables invariably bear main stress.

As for acoustic realization of stress, i.e., the phonetics, salience of the stressed syllable can be achieved by bringing greater prominence to the properties duration of the syllable – or rhyme in ms –, intensity, pitch and manner of articulation. These properties, which are also referred to as *prosodic* or *supragemental* features, provide the listener with acoustic information to where the stressed syllable is located. Another characteristic of suprasegmental features is that they can serve to encode segmentation and therefore contribute to the communication process. By means of these features, the listener is able to parse speech into various linguistic levels, such as word and phrases. Accordingly, through prosody one can infer word and phrase boundaries (Sluijter 1995; Van der Hulst 1999).

From a typological viewpoint, stress languages as Dutch and BP have acoustic correlates as duration and loudness associated to the stressed syllable (Beckman 1986). Yet there has been some misunderstanding concerning what represents stress and accent correlates, which we find worth mentioning here. Stress correlates differ from accent correlates in that the former marks prominence of the stressed syllable; accent correlates, on the other hand, gives prominence not only of the stressed syllable in a word, but also of a group of words. A syllable or word bearing an accent-lending tone [2] (High, Low or a combination of both) carries the most important information the speaker wants to convey. When a syllable or word carries an accent lending movement, these units are put in *focus position*. By doing this, the speaker may direct the listener's attention to the "new" or most important information the message carries. Information that is in focus position is realized with"[…] a pitch accent on the prosodic head of the word (group)" (Sluijter 1995). When in focus position, a change in pitch is also found in stressed syllables. Furthermore, pitch accent can be present in stress languages as a prominent, if not the only acoustic correlate. This is the case of French and Polish (Beckman 1986). The similarity between these two languages is that they both have fixed stress. In section 2.2 we will return to this issue, bringing some evidence that stress languages can have different ways of presenting phonetic prominence of stress, which may be related to their phonological classification.

Accordingly, we shall treat stress and accent as separate concepts. At the word level, stress is a phonological property that expresses prominence of a syllable in relation to unstressed ones. Stress has phonological and phonetic correlates. When a word is in focus position, the stressed syllable usually receives extra phonetic prominence by having a pitch-landing accent associated to it. Thus stress is part of the language's structural system and can always be identified even when the word is unaccented. On the other hand, accent highly dependents on how the speaker wants to transmit a message. By accenting a morpheme, a word or a group of words, the speaker puts these in focus and makes it easier to the listener to pay attention to the most important part of the message. That is, it is highly dependent on the language behaviour (Sluijter 1995).

In sum, metrical theory classifies languages mainly as weight-dependent and non-weight dependent, for which in the former as opposed to the latter, syllable configuration has a high influence

[2] According to Gussenhoven (1988), pitch amounts to the auditory sensation of tonal heights. It is intrinsically related to the number of periodicity in the acoustic signal. A period refers to repeated vibrations (closing and opening) of the vocal cords. Different segments have different quality sounds from which different shapes in pitch determine the sound being uttered. Prosodic prominence can also be achieve by means of autosegmental representation of tonal structure. Following Gussenhoven, autosegments are represented by a succession of high (H) and low (L) tones within a phrase or sentence. Pitch is the phonetic correlate of tone structure, and can be realized by a rise or fall tone movement, or even a mix of these two.

in identifying the most prominent syllable. In phonetic terms, on the one hand, auditory correlates of stress are highly dependent on the language system, which in turn reflect the stressed syllable at the word domain. On the other hand, correlates of accent reflect how a word, or a string of speech has been uttered concerning its communicative importance. The previous descriptions contribute to the understanding of the sections to come, given that previous investigations of stress realization usually suffered from stress and accent co-variation.

2.2 – Word stress correlates in German and in Polish

It is known that languages which are typologically distinct mark stress differently in the acoustic domain. This hypothesis was checked by Dogil & Williams (1999 in an experiment involving languages representing distinct metrical systems: German (weight-sensitive) and Polish (weight-insensitive). The importance of Dogil and Williams's investigation to the present study comes from some evidence, albeit still quite little, that stress behaves differently between these languages with regards to phonetic acoustic prominence. The assumption is that such distinction may be related to the phonology that underlies each language system, in that acoustic correlates of stress in weight-sensitive languages is by far more acoustically prominent than in weight-insensitive languages.

Metrical phonology classifies German as a weight-sensitive language (Jessen 1999). Branching rhymes, that is, heavy syllables, are usually stressed. Thus word stress has a contrastive function in German, for which main stress obeys the three-syllable window restriction. This is to say that there is a limit of syllables into which stress can fall. Only the three syllables, counting from the right edge of the word, can bear primary stress. German phonology does not count long vowels as heavy; i.e., vowel length does not predict stress location.[3] Despite being a weight-sensitive language, German counts with few exceptions for which stress is marked in the lexicon.[4]

It has been long tradition among phoneticians to investigate phonetic correlates using minimal pairs. Minimal pairs are lexical items that are segmentally equal, but differ in the position of the stressed syllable. In English, *forBEAR* and *FORbear* is an example of a minimal pair. In Dutch *VOORnaam* "first name" and *voorNAAM* "respectable"; in German '*MOdern* "to disintegrate" and *moDERN* "modern"; in BP *saBIa* "to know" (1st person past imperfect) and *sabiA* "kind of bird". The biggest challenge of investigating minimal pairs is the way it has been conducted, which resulted in controversial results. A common drawback of such experiments was that the context in which the minimal pairs were inserted was not controlled for. This is to say that accent and stress correlates were confounded. The reader is referred to Issatchenko & Schädlich 1966, Goldbeck & Sendlmeier 1998

[3] For alternative analyses, where vowel length contributes to syllable weight, the reader is referred to Wurzel 1970, 1980; Giegerich 1985; Féry 1986; Yu 1992; Ramers 1992. In line with these analyses, -VC are considered light syllables as the closing consonant is taken as extrametrical; while –VV(C) and –VC (C) are both heavy given the long vowel and the closed syllable respectively.
[4] The reader is referred to Jessen (1999) for a detailed description of the German word stress system.

and Jessen & Marasek 1995 (cited in Dogil & Williams 1999) for a thoroughly description of experiments on German stress correlates.

Dogil and Williams (1999) investigated acoustic correlates of word stress in German using minimal pairs, which in turn were inserted in sentences in which context guaranteed neutral position for the words. By doing this, correlates of word stress would not be confounded with accent correlates. The results showed that syllable duration turns out to be the main correlate of primary stress in German. This result was confirmed by the difference between the stressed and the unstressed vowel versions, for which the latter was shorter in duration and presented a reduced spectral structure (1999: 292). In addition to this, there was a noticeable F0 change upon the stressed syllable. The results above were further confirmed in another experiment in which the nonsense word *mamamamama* appeared in focus and non-focus positions. Reiterant speech, as this method is called, is employed in order to verify acoustic correlates as "investigating neutral words is better [since] the inherent acoustic properties of individual sounds may falsify the results" (1999:295; see also Liberman & Streeter 1978). Again the results showed that duration is the main correlate of lexical stress in German for both focus and non-focus conditions.

While in German there is a noticeable difference in prominence within a foot involving the stressed and the unstressed syllable, the same does not seem to hold for many weight-insensitive languages. In contrast to German, metrical analyses classify Polish as a weight-insensitive language. This is due to the fact that in Polish main stress has a culminative function, and accordingly it is always located at the same syllable position: the penultimate syllable. As a result, Polish does not have vowel length distinction, which together with branching rhymes, does not have any influence in stress assignment. Thus stress location is predictable as it always falls on the penultimate syllable, counting from the right-edge of the word (Dogil et al. 1999).

As to check the acoustic correlates of word stress in Polish, a similar experiment to that of German was conducted. This time, stress correlates were measured in non – focus, as well as in broad and narrow focus positions employing the constituent *marmoladowymi* "marmalade" , whereby the penultimate syllable /wy/ receives primary stress. For the three conditions, F0, syllable length and vowel quality were measured across three native speakers of Polish.

The outcome was as follows. In the non-focus condition, F0 was the only significant correlate of penultimate stress; whereas syllable length and vowel quality were higher for the secondary stress of the initial syllable /mar/. Although F0 is slightly high on penultimate stress, it casts doubt on whether this results is indeed significant when it compared to the remainder of the syllables. Conversely, F0 does not correlate neither to primary nor to secondary stresses when the word is in broad focus. The authors attribute this to the "interdependence between lexical stress and intonational structure of Polish", for which in broad focus position no pitch accent is associated to stressed syllables. Due to this, stress in Polish is seen as "weak" as "F0 only marks a position for the association with the nuclear pitch-accent morpheme of a sentence" (1999: 287). As for vowel quality, most of the syllables, except the unstressed /mo/ and final /mi/, had a reduced quality. However, this correlate did not interact with syllable length, for which the final syllable /mi/ reached the same relative duration of the main stressed syllable /wy/. Further, in narrow focus position there was also an increase in F0. However, vowel quality remained the same across syllables, and vowel length turned out very similar between stressed and unstressed counterparts.

Interestingly, similar results of that for Polish were also found for Spanish. Most accounts on Spanish metrical system classify this language as weight-insensitive (Alcoba & Murillo 1998). Stress location cannot be established given the nature of the sequence of phonological segments alone. Also, stress position is highly dependent on the lexical category (verbs and non-verbs) and morphological structure (Harris 1983; Den Os & Kager 1986; Alcoba & Murillo 1998). [5] The similarity with Polish is that, despite stress has a distinctive function in Spanish, 80% of main stress falls on the penultimate syllable, and stressed and unstressed syllables are mostly of the same length.

Dogil and Williams showed that there is an increase in F0 between main and secondary stressed syllables in Spanish. Further, no difference in duration and vowel quality was found between the secondary and the unstressed counterparts, when these were compared to main stressed syllables. Thus syllable prominence was only marked by means of a high F0. Accordingly, the results suggest that in Spanish, the lack of phonological correspondence may level out stressed and unstressed syllables, as measurements of duration and vowel quality do not vary. Thus, analogous to Polish, when words are in focus position, F0 appeared to be the only correlate to mark acoustic stress prominence in Spanish.

Overall, Dogil & Williams's investigation suggests that stress correlates of primary stress in Polish, as well as in Spanish, are subtle if one considers the duration of syllables in main and secondary stress positions. And although their investigation is quite limited in the sense of number of tokens and speakers, one can infer that stress correlates (vowel duration, and vowel quality) do not differ across syllables, especially with regards to the main stressed syllable. What can be observed is that, depending on the context, F0 manifests upon the stressed syllable when it is locus of intonation; that is, it is context dependent. Thus phonetic manifestation of word stress and intonation morphemes are directly associated, and therefore, Polish and Spanish may present a weak stress phonetic implementation.

Dogil & Willimams's investigation brought about a worthy contribution to the understanding of how languages of different metrical systems can differ concerning the way they mark stress in the acoustic domain. The difference in how stressed and unstressed syllables are realized positions German in a different rhythm than that of weight-insensitive languages. Thus a reduced-unstressed syllable helps in the acoustic implementation of a full-stressed syllable. However, if for Polish, stress

[5] For a complete description of the stress system in Spanish, the reader is referred to Harris (1983).

is invariably at the same location, and words are never contrasted by means of stressed syllables, it is to expect that a marked acoustic stress prominence should not be necessary. Thus, in comparison to German, Polish seems to be in great disadvantage. In addition, Polish and Spanish may be similar to the extent that in both languages, temporal realization of stressed and unstressed syllables do not seem to differ considerably. Yet, in Spanish, stress has a distinctive function, and duration and pitch, are sufficient prosodic cues for the identification of stressed syllables (Soto-Faraco et al. 2001). Thus, it seems reasonable to assume that, even though duration of stressed syllables may not be as marked as in German, a weight-sensitive language, it still guides Spanish listeners in the identification of correct lexical items all the same.

Accordingly, our hypothesis here is that stressing a predominant syllable position may disregard the need of more prominent stress correlates. This may be because in very few instances a speaker of Spanish, as well as of BP, have to stress other syllable patterns than that of the penultimate position. In the same line of reasoning, it is also not sure whether a greater phonetic acoustic prominence realization of stress can be associated to the metrical classification of a language; i.e., the weight-sensitive nature. Yet, we assume that the greater possibilities of stress locations, as a function of syllable weight, may induce a speaker of a weight-sensitive language produce stronger phonetic correlates of stress, which in turn can become even more perceptually salient than in a weight-insensitive language, when an unstressed reduced syllable is realized. Yet, as we will see in chapter 4, this may be conditioned to whether or not segmental information is employed as a stress cue. In this case, prosody has a key role in word recognition.

Chapter 3 – The phonetic manifestation of word stress in Dutch and in Brazilian Portuguese

3.1 Acoustic correlates of word stress in Dutch

In terms of how word stress is phonologically and phonetically represented, Dutch can be largely compared to German. BP, in turn, is similar to Polish in that it has been classified as a weight-insensitive language, in which most of the stress patterns fall on the penultimate stress. However, stress has a distinctive function, and acoustic correlates of stress are extensively exploited in lexical identification in BP. If weight-sensitive languages can be assumed to have more prominent phonetic correlates of stress than weight-insensitive languages, it seems reasonable to compare two languages in which the function of stress works in a similar fashion. Therefore, we believe that Dutch and BP can be directly compared in this respect.

The assignment of word stress in Dutch has been studied extensively by metrical phonologists such as Trommelen & Zonneveld (1999), Kager (1989) and many others. The general consensus among these phonologists is that Dutch is a weight-sensitive language, in which long vowels are not stress-attracting. Accordingly, stress placement can be highly dependent on the position of the word's rightmost heavy syllable. More importantly, the high number of language-specific exceptions results in different positions for stress placement. Thus main stress location in Dutch, in addition to being easily predicted from the position of the heavy syllable, can also be highly irregular and dependent on various exceptions, which in many cases cannot be easily explained. Again, following Dogil & Williams, the hypothesis is that languages such as Dutch and German that allow more varied distribution of stress location (probably as a function of syllable weight) may have a different realization of stress in comparison to languages in which stress system is quite fixed.[6] As a result, weight-sensitive languages such as Dutch may need have a more prominent acoustic stress realization, as listeners should also rely on such cues for word recognition.

Concerning how Dutch stress is realized in the acoustic domain, Sluijter (1995) showed that duration was the most robust cue, followed by spectral balance (the amount of energy distribution across the four frequency bands, (Quené 2006)), vowel quality (by measuring formant frequencies) and lastly by overall intensity. She measured the realization of these correlates, for stressed and unstressed syllables for the Dutch minimal pair *CAnon* "dogma" – *kaNON* "cannon", and a reiterant counterpart *NAna* and *naNA*. Targets were realized in focus [+F] – with the presence of an accent-lending pitch movement –, and in non-focus [-F] positions – with the pitch accent being realized in the word following the target, as to avoid accent confounding.

The results showed that vowel quality is a poor correlate of stress. The difference in focus and non-focus conditions did not cause a significant effect involving the formant measurements (F1, F2,

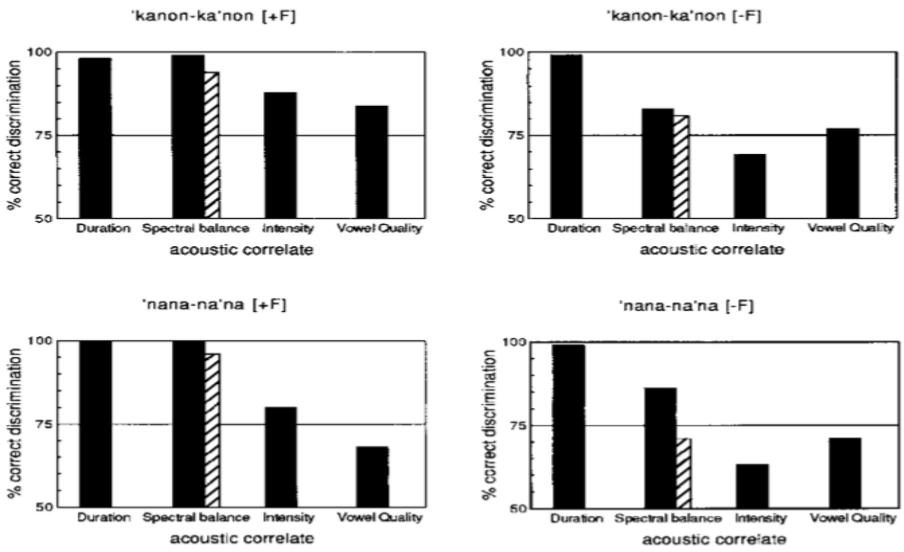
[6] The reader is referred to Kager (1989) and Trommelen & Zonneveld (1999) for a thorough description and explanation of Dutch stress assignment.

F3 and F4), for both lexical and reiterant targets. This result seems to be compatible to role of vowel quality as a perceptual cue to stress. As we will see in chapter 4, despite the fact that Dutch does employ vowel reduction in unstressed syllables, this information (a reduced vowel quality) does not seem relevant for stress perception. Considering syllable duration, stressed syllables were found to be significantly longer than the unstressed counterparts. Also, the results showed that there are no significant differences in syllable duration between [+F] and [-F] conditions for both lexical and reiterant targets. Accordingly, duration turns out as a reliable acoustic correlate of stress, which remains robust even if not under the influence of a focus accent.

In contrast to previous experiments (Fry 1955, 1958), Sluijter's results revealed that intensity did not bring about changes between stressed and unstressed vowels in the [-F] condition. However, a considerable change was found in the [+F] condition between stressed and unstressed vowels for both lexical and reiterant versions of the targets. As a result, there is a considerable difference in overall intensity caused by a high F0, which consequently has an increase in glottal pulses in stressed syllables in relation to the absence of these correlates in the unstressed vowel. The absence of a difference in overall intensity in the [-F] position gives evidence of the poor communicative nature of this correlate for stress perception. Conversely, the considerable increase in intensity only in the [+F] condition can be better interpreted as a correlate of accent instead. Thus, the expectation is that the listener would find it difficult to judge stressed and unstressed syllables just by means of overall intensity.

Further, spectral balance turned out as a strong correlate of stress, even comparable to duration. The differences between stressed and unstressed syllables were measured by calculating the overall intensity in the four regions of the spectrum, for which higher intensity distribution was found to be located in the higher filter bands. The assumption is that intensity is higher in the higher filter bands because the stressed syllable is usually realized with more effort. As a result, there is an increase in the "pulse-like shape of the glottal source signal" (1995:66), which are then different in stressed and unstressed syllables. A stressed syllable is realized by means of a faster closure of the glottis, which results in a pulse-like with "greater excitation". As a result, the harmonics will be more flat-like. In contrast, in an unstressed syllable the closure of the glottis is slower, resulting in a more gradual pattern of the closure, which in turn results in a negative spectral slope. Figure 1 below, from Sluijter (1995), illustrates the strength of each correlate in the realization of main stress in Dutch for target words in [+F] and [-F] positions.

Figure 1, from Sluijter (1995). Overview of the percentages correct discrimination for each acoustic correlate of stress. The upper figures present the lexical speech tokens; the lower figures present the results of the reiterant speech tokens, for both [+F] and [-F] conditions. The percentages correct for the corrected spectral levels are presented by a hatched bar, the uncorrected data by the black bar.



From Sluijter's investigation, there is no doubt that duration is a robust acoustic correlate of stress in Dutch, as it is invariable under [+F] and [-F] positions. Close to it is spectral balance, in which stressed syllable are distinguishable from the unstressed counterparts given that more intensity is spread across the higher frequency bands as a result of greater physiological effort. Vowel quality and intensity are very poor indicators of stress, and the latter can even overcome vowel quality when in focus position. However, this investigation is limited to us in the sense that only two-syllable words were used. It would be interesting to know, for example, if the realization of Dutch stress correlates differs concerning three-syllable words. Thus investigating longer words would give as an indication of whether one stress pattern is more forcefully realized than another, and how they can be compared to the unstressed counterparts. Also investigating three-syllable words would help us predict how stress is therefore perceived in different syllables patterns, not only by Dutch listeners, but also by BP listeners when BP stimulus words are produced by a Dutch speaker.

3.2 Acoustic correlates of word stress in Brazilian Portuguese (BP)

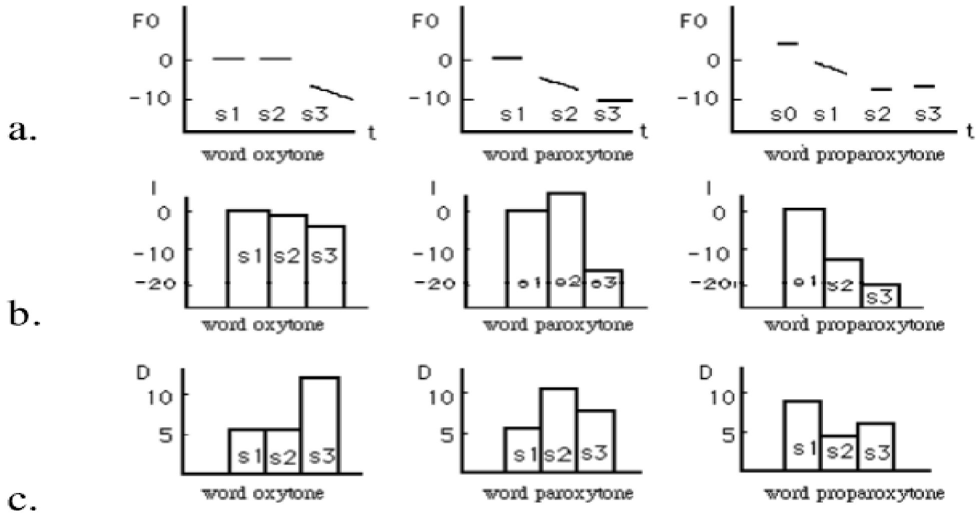
In contrast to Dutch, BP stress system has been classified as weight-insensitive, for which primary stress is restricted to the last three syllables, also from a right-to-left fashion (Lee 1995; Mateus and D'Andrade 2000). Accordingly, stress assignment is said to depend on the lexical category: nouns and verbs. There are, however, proponents of a weight-sensitive system for BP (Bisol 1996; Wetzels 2007). The assumption in this view is that stress is weight-dependent, and this assumption is mainly based on empirical evidence that new words entering the BP vocabulary usually receive stress on closed syllables: e.g.: aroTIN, feneREN, cimBALta (pharmaceutical names) (Herman & Wetzels 2012). Yet, although linguists have disagreed on the nature of the BP stress system, it does not change the fact that this language has a very regular stress location. In most words of the lexicon, the penultimate syllable is stressed, and there are very few instances of the other two possible stress positions: the antepenultimate and final syllables.

In order to describe and disentangle the difference between stress correlates realization in BP, with and without the accent confounding, Moraes (1995; 1998) made use a corpus containing 36 sentences uttered by 8 BP native speakers. Stress and accent correlates were investigated taking into consideration the position of the stressed syllable, i.e., final, penult and antepenult. Accordingly, each of these stress patterns were investigated regarding the word position within a sentence; i.e., beginning of phrase, middle of phrase and end of phrase or sentence. The latter condition being classified as focus condition, and the first two as non-focus condition, employing a declarative mood.[7] Combinations were constructed making use of nonsense words in various positions within a sentence. That is, for the sentence *Ele viu o sabiA* "he saw the bird", *sabiA* was replaced by the nonsense word *pipiPI*, which also received final stress. By the same token, penultimate and antepenultimate stressed words were also replaced by nonsense words, which in turn were stressed accordingly.

The results revealed that in focus position, primary stress is realized by a combination of F0, intensity and duration. Figure 2 below exemplifies the acoustic correlates for the nonsense word *pipipi*, in response to the sentence *Porque Pedro está assim? Ele viu o* ***pipipi***. "Why is Pedro like this? He saw the ***pipipi***", with final, medial and initial stress positions.

[7] For the purpose of this thesis, we will be only reporting the results concerning declarative sentences, in focus and non-focus positions. Also, we decided to report only results of target words in end of sentence (focus position), and middle of phrase (non-focus position), given that there was no difference in acoustic correlates of stress for targets in other sentence positions for the respective conditions. The reader is referred to Moraes (1995; 1998) for a thoroughly description of the BP acoustic correlates of stress in other sentence modalities and position of words within sentences.

Figure 2, from Moraes (1998). Acoustic correlates of stress at the end of a sentence (focus position). (a) F0 in quarter tones; (b) intensity (I) in decibels; (d) duration of vowels in centisenconds. S1, S2 and S3 stands for antepenult, penult and final syllables respectively. S0 represents the pre-antepenultimate syllable. Word stress is referred as oxytone (final stress), paroxytone (medial or penultimate stress) and proparoxytone (initial or antepenultimate stress).



As we can see, for antepenultimate- and penultimate-stressed words there is an increase in intensity, which is then marked by a considerable fall of this correlate in post-tonic position, and keeps falling on in the subsequent post-tonic syllables. An opposite pattern is noticed for final stressed words. Instead of an increase in intensity in the final-stressed syllable, this decreases; there is a very subtle difference in intensity between the final syllable and the previous ones instead. As for duration, it turns out as a strong correlate in all the stressed patterns. The duration of the stressed syllable in strong position is acoustically more prominent than the unstressed ones. Further, for Moraes F0 turns out to be the strongest correlate of lexical accent, outranking both duration and intensity. In a perception experiment, also by Moraes (1998), F0 has proved to be more effective than duration: the accent, by means of F0, is superimposed on the stressed syllable, at the utterance level. There is a rise – fall pattern in stressed syllables in declarative mood (focus position) in relation to the previous unstressed syllable, which keeps falling in post-tonic positions.

In non-focus position, stress is realized as a combination of intensity and duration. Again, analogous to stressed-syllable words in focus position, the stressed syllable in non-focus position is realized with longer duration. And intensity usually drops off on post-tonic position.

Figure 3, from Moraes (1998). Acoustic correlates of stress within a sentence (non-focus position). (a) F0 in quarter tones; (b) intensity (I) in decibels; (d) duration of vowels in centisenconds. S1, S2 and S3 stands for antepenult, penult and final syllables respectively. S0 represents the pre-antepenultimate syllable. Word stress is referred as oxytone (final stress), paroxytone (medial or penultimate stress) and proparoxytone (initial or antepenultimate stress).

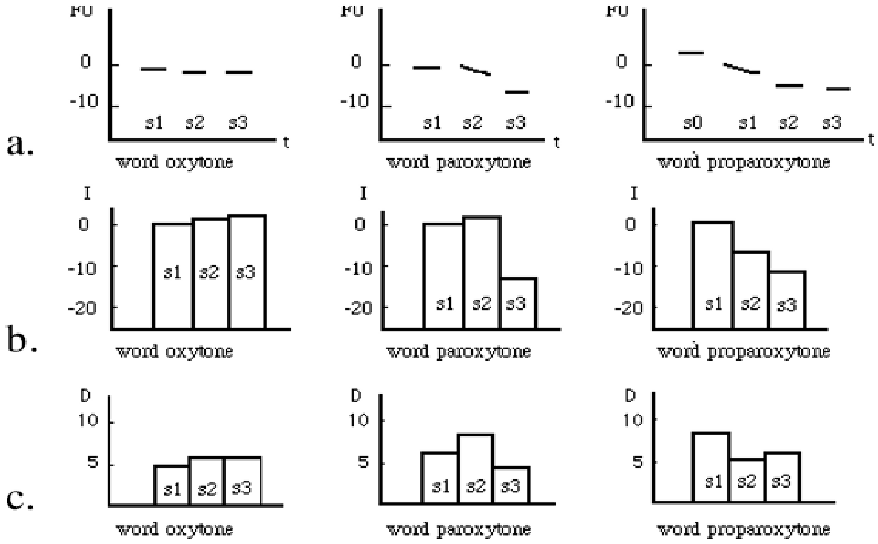


Figure 3 exemplifies the acoustic correlates for the nonsense word *pipipi* within a declarative phrase (non-focus position): *Quando Pedro viu o pipipi*? Ele viu o ***pipipi*** quando saía de casa. "When did Pedro see the pipipi? He saw the ***pipipi*** when he was leaving home". Accordingly, we see that there is hardly any difference in intensity between syllables for final-stressed words. Intensity is more prominent in penultimate-stressed syllables, for which a distinction is then noticed by a decrease of this correlate in post-tonic position. Also, antepenultimate-stressed syllables are marked by a considerable fall in intensity in the following syllables, which keeps dropping off in subsequent syllables, reaching its lowest point in the final syllable. This stress pattern is, in turn, realized with stronger intensity in comparison to the other two stress patterns.

Duration shows prominence for penultimate- and antepenultimate-stressed words. For the final stress pattern, it seems that there is no prominent acoustic correlate given that the penultimate and final syllables are very similar in duration. Moraes explains that when the syllables are realized with similar prosodic weight, stress is then perceived on the final syllable. Similarly, F0 does not show any prominence in final-stressed syllables comparing to the other two stress patterns, where there is a fall-rise in F0 upon the stressed syllable, which keeps falling in post-tonic position. F0 fall in penultimate and antepenultimate syllables is corroborated by the fall in intensity in post-tonic syllables.

Given the descriptions above, stress and accent are realized differently as a function of the position the target word occupies in the sentence. The main distinction concerns F0 realization, which is less prominent in non-focus position and has a minor contribution to the realization of the stressed syllable. In contrast, in focus position, besides bringing extra prominence to the stressed syllable, it is also the correlate par excellence of phrasal accent, indicating the communicative role of the sentence according to an intonational pattern.

As for intensity, except for final stress, the author claims that this correlate behaves very similar in weak and strong positions for penultimate- and antepenultimate-stressed words. Yet, it is worth recalling that intensity has been proved to be a weak stress correlate, due to its unreliable contribution in identifying the stressed syllable at the word level. As Sluijter (1995:65) showed for Dutch, there is a considerable difference in overall intensity between stressed and unstressed vowels in focus condition. This change can be attributed to the higher number of glottal pulses being realized in the same time span, which can also lead to a larger amplitude as a consequence of a higher pitch movement. Similarly, we believe that this could not be different in BP words in the same condition. Hence, the role of overall intensity as a stress correlate in BP should be revised, as evidence shows that it is more likely that it is an accent correlate instead.

The realization of duration, in turn, is less marked in non-focus than in focus positions given that this correlate fails to behave as a prominent stress mark in final-stressed words. According to Moraes, penultimate and antepenultimate stressed syllables are 66% longer than its unstressed counterparts, and there is no significant difference in this correlate between strong and weak positions for these stress patterns. In contrast, the difference between final-stressed words in strong and weak positions is that in the latter stress is realized and therefore perceived by the similar weight between the adjacent syllables (there is an increase of 12% in the temporal realization of the final-stressed syllable in comparison to unstressed syllables). In focus position, the final syllable is longer: an average of 31% (end of phrase) and 152% (end of sentence). For the latter, there is a considerable increase in duration as a consequence of lengthening of the final vowel (Moraes 1995).

For the author, the behaviour of the final-stressed syllable in non-focus position is readily justified by the fact that there is no need to have an increase in duration for this syllable be perceived as stressed when the preceding ones are also similar in duration (1995: 57). However, what seems contradictory in this assumption is that it is possible that stress can be perceived in the penultimate syllable instead, due to a reduction of the prosodic parameters in the final syllable. Thus, we assume that, at least in three-syllable words, when the first two syllables have similar prosodic weight, the reduction in the acoustic parameters in the final syllable may result in a perceptually more prominent previous syllable; that is, in the penultimate syllable, which represents the default-stress pattern in BP. So it is possible that in a word recognition experiment as the one described in the present study, participants may delay their choice of recognizing a word as they may be biased by the similar prosodic weight of the antepenultimate and penultimate syllables, for words pronounced with correct-final stress.

In sum, acoustic correlates of lexical stress in BP has duration as its most prominent correlate. This was observed by the measurements of stressed syllables of words that occupy a non-focus position in a sentence. Stressed syllables are longer than the unstressed counterparts. Duration only fails to mark prominence in final-stressed words in non-focus position, for which this stress pattern is perceived when previous syllables have similar temporal weight. However, the preceding raises the question as whether duration may be as perceptually prominent in BP as it is in Dutch. Although duration is the correlate par excellence in BP, other investigations have shown that unstressed vowels are not reduced (Meireles et al. 2010).[8] As a result, the absence of an alternation between full stressed and reduced unstressed syllables may posit BP in a different phonological and phonetic rhythm than that of Dutch.

Accordingly, one could ask what would be the impact of such rhythmic difference in stress perception. [9] It seems that languages that have been classified as weight-sensitive are more likely to have temporal differences between stressed and unstressed syllables. This question, however, goes beyond the scope of the present thesis. More importantly is whether languages that allow a more even distribution of stress across a word's syllable, such as Dutch, may be more acoustically prominent in the perceptual domain than a weight-insensitive language, such as BP, since in the latter type word stress almost always falls on the same position. Thus, a perception experiment conducted with BP listeners, in which Portuguese words are produced by both Dutch and BP speakers can give us a clear indication of which language stress is more perceptually prominent.

In the next section, we present statistical distribution of stress patterns in Dutch and in BP. The hypothesis is that stress cues produced by Dutch native speakers are perceptually more prominent than that of BP native speakers. Thus we presume that the different L1 BP and L2 BP stress realizations can be a result of different possibilities of stress location. Should this hypothesis be correct, it shall bring consequences for stress perception involving BP as L2 when produced by a Dutch speaker.

3.3 Frequency distribution of word stress patterns in Dutch and in BP

Because in weight-sensitive languages, stress is dependent on where the heavy syllable is located, distribution of stress patterns can vary considerably. Van Heuven & Hagman (1986) showed, based on the CELEX word-list (Kerkman 1986), the percentages of each stress pattern in Dutch. This database comprises of approximately 70,000 monomorphemic and complex (compounds) Dutch words. Firstly, it shows that despite penultimate stress may be preferred among monomerphemic words, stress position in antepenult and final syllables are still considerably high. Secondly, when the calculation includes all the words of the lexicon – that is, monomorphemic and complex words – we notice that it is possible to reach a more equal distribution of stress positions.

[8] The reader is referred to Meireles et al. (2010) for a complete description of the experiment.

[9] We want to be clear here that we are not arguing in favour of rhythmic classes for languages, although we do believe that previous investigations on this subject can, to some extent, give an indication of the amount of vowel reduction languages employ in unstressed syllables. Instead, we want to say that in some languages, as in Dutch, vowels in unstressed syllables are differently realized than in BP, which consequently results in a different rhythmic pattern. For a discussion about rhythmic classes, the reader is referred to Abercrombie (1967), Ramus et al. (1999), Frota & Vigário (2001), Grabe & Low (2002), White & Mattys (2007a,b), Meirelles et al. (2010) and Arvaniti (2012).

Table 1 below shows the statistical distribution of stress patterns in Dutch for monomorphemic words. The rows comprise of the number of syllables in a word, whereas the columns indicate the position of the stressed syllable.

Table 1, from Van Heuven & Hagman (1988), using data from CELEX (Kerkman 1986). Absolute and relative numbers of lexical frequency of Dutch stress patterns in monomorphemic words. The most left vertical line presents the word length in syllable number; the horizontal line presents the stress pattern.

Word length	Position of main stress in monomorphemic Dutch words				
Number of syllables	**Pre-ant.**	**Antepenult**	**Penult**	**Final**	**Total**
2			2703 62%	1682 38%	4385
3		408 18%	808 36%	1032 46%	2248
4	56 6%	128 13%	474 49%	314 32%	972
total	5	536	3.985	7.312	11.889

As the data indicate, monomorphemic words have a modest preference for penultimate stress. Disyllabic words, for example, amounts to 62% of this pattern. Similarly, four-syllable words are stressed on the same position in 49% of the cases. As for trisyllabic words, final stress outnumbers other stress positions, counting 46% of the total stressed syllables. Yet 36% of the stressed syllables receive penultimate stress.

When complex words are included in the analysis the following results are obtained. Two-syllable words are very frequent, and initial stress prevails, counting 85% of the stress position. Similarly, 67% of the three-syllable words are also modestly more stressed on the antepenultimate syllable. Given that initial stress is the most common one in Dutch, it turns as the default pattern in Dutch. However, the longer the word, the more spread are the stress patterns across the possible syllable positions. Observe that 45% of four-syllable words also receive stress in the initial syllable; that is, the pre-antepenultimate syllable. Van Heuven and Hagman explain that this may be due to the fact that Dutch compounds are usually stressed word initially. Interestingly, one can observe that there is no specific preference for stress location in other positions as the word size increases, which leads to more equal distribution of stress. Table 2 represents all the words in lexicon, monomorphemic and complex words in Dutch.

Table 2, from Van Heuven & Hagman (1988), using data from CELEX (Kerkman 1986). Absolute and relative numbers of lexical frequency of Dutch stress patterns in monomorphemic and polymorphemic words.

Word length	Position of main stress in monomorphemic and in polymorphemic Dutch words				
Number of syllables	**Pre-ant.**	**Antepenult**	**Penult**	**Final**	**Total**
2			15758 85%	2726 15%	15758
3		18020 67%	6370 24%	2606 9%	26996
4	6436 45%	3365 24%	3065 21%	1278 10%	972
total	6436	5167	19460	6610	31063

Following Van Heuven and Hagman (1988), the following considerations can be drawn from the table above. Concerning speech perception, stress information contributes to word recognition when the target word is still being uttered. Should it be monomorphemic or complex words, the position of the stressed syllable shall help eliminate undesirable candidates, shrinking the search space by just listening to short word fragments. By the same token, the lack of prosodic information at the beginning of a word may limit the number of possible candidates in word recognition.

The following data on the stress patterns distribution of BP word stress come from the FrePOP (frequency of phonological objects in Portuguese) presented in Post (2013). Despite metrical phonologists disagree with regard to whether BP is weight-sensitive or not, statistical distribution shows that more than 70% of the words receive penultimate stress. Disyllabic words are the most recurrent pattern, amounting to a total of more than 50%. Final stress is the second most frequent, counting 26% for disyllabic words and approximately 20 % for three- and four-syllable words. Antepenultimate stress is the less recurrent pattern, and that amounts to 6% and 8% of the stressed syllables in three- and four-syllable words respectively. The picture below illustrates the statistical distribution of primary stress position in monomorphemic and complex words in BP.

Table 3, from Post (2013). Absolute and relative numbers of lexical frequency of BP stress patterns in monomorphemic and polymorphemic words.

Word length	Position of main stress in monomorphemic and in polymorphemic BP words			
Number of syllables	**Antepenult**	**Penult**	**Final**	**Total**
2		456450 74%	157580 26%	614030 53%
3	20716 6%	256166 75%	66831 19%	343713 30%
4	16250 8%	143628 72%	38835 20%	198713 17%

Based on the information on table 3, it is clear that in BP, independently of word size (monomorphemic or complex words), 75% of the total words receive penultimate stress. BP differs from Dutch in that stress patterns in Dutch are more equally distributed. Thus one could assume that words longer than two syllables in Dutch may have similar chances to be stressed in one of the syllables of the three-syllable window.

Accordingly, one could infer that in weight-sensitive languages the greater functional load of stress in different syllable positions may result in a greater phonetic prominence of stress when compared to languages that position of stress is invariable. In languages that stress placement is mobile – that is, where stress is contrastive – minimal pairs that are semantically identical can be identified by means of prosodic cues. This is the case of German and Dutch. The more the possibilities of stress location, the more the use of prominent acoustic correlates in the realization of stressed syllables in comparison to weight-insensitive languages. In Polish, where stress is invariably at the same position, words are never contrasted by means of stress position, and therefore there may be no need for a more implemented phonetic realization of stress.

A question that arises, however, is whether stress prominence in Dutch should be similar in all syllable positions, or if it is more prominent in initial syllables. This assumption should be considered given that initial stress is the default pattern in Dutch. Thus an interesting thing to look at is how BP correct-stressed words with initial stress produced by the Dutch L2 BP speaker are perceived by the BP listeners when these are compared to the L1 BP version thereof. In case initial-correct stress produced by the Dutch speaker has a recognition advantage over the BP realization, and the other correct positions (medial and final), it is a strong indication that, although other syllable positions have similar chances to be stressed, Dutch speakers still rely on the default initial position for the production of more prominent acoustic correlates.

The previous thought is by no means strange, since research has shown that, concerning the production of stress, speakers can be highly guided by the first language's default pattern. By means of example, Post da Silveira (2012) showed that BP speakers of English as L2 correctly produced stress patterns existent in the target language in 70% of the cases when the English word received penultimate stress. The interesting result of Post's investigation is that the error patterns produced by BP speakers of L2 English also favoured prefinal syllables, giving evidence that the subjects rely on the regularity of stressing penultimate syllables in a similar fashion as in their native language. Accordingly, another question that arises is whether the penultimate pattern may also bias BP listeners in the perception of the most prominent stressed syllable. Our hypothesis is that since penultimate stress the most expected, it should also be the one most and faster recognized. By the same token, BP listeners may take longer to recognize wrong stress produced on medial position, as well as this incorrect stress pattern may reach very high error scores, since speakers may think that they are indeed listening to a word with penultimate stress.

What is more, a more equal distribution of stress patterns may not suffice to produce greater stress prominence, which in turn can lead to a more perceptually prominent stressed syllable, when compared to a language with one predominant stress position. Added to this, greater prosodic prominence may signal lack of phonological correspondence to stress cues. That is, when segmental difference does not count for stress perception, acoustic correlates of stress may indeed be more perceptually prominent in weight-sensitive languages. In the next chapter we present various experiments about the importance of stress in word recognition. This mainly involves Dutch listeners and addresses the question as to how successful they are in recognizing words by means of prosodic information only. This success may be related to the distribution of stress patterns in Dutch, which together with lack of segmental cue to stress make Dutch speakers exploit to a great extent acoustic correlates of stress for lexical identification. In the same chapter, we also present an investigation on BP perception of primary stress, followed by the research questions we will attempt to answer in this thesis.

Chapter 4 – Perception of stress in word recognition – the case of Dutch and BP listeners

4.1 Segmental and prosodic information in word recognition

Incoming auditory information involves the activation of many word candidates that listeners exploit for the benefit of speech processing. When words, in a stream of sounds, enter the auditory system, "an accurate and detailed image of the actual speech sound is available to the listener" for about 100ms, and it usually lasts around 250ms until it starts to decrease (Van Heuven & Hagman 1988: 1; see also Crowder & Morton 1969; Massaro 1972). Thus since the first moment the auditory stream is accessed, the listener makes great use of earlier information, as word onsets, in order to recognize words (Van Heuven & Hagman 1988; Van Heuven 2008). For instance, an English speaker listening to the first three phonemes *mus*, his memory will activate the most frequent words that start with the same sequence: e.g., *mus*ic, *mus*cle, *mus*hroom, *mus*eum, etc., and consequently will inhibit all the others that do not match the similar onset phoneme configuration.

Research contribution on speech perception concerning word recognition by means of segmental information has been remarkable. Segmental information has proved to be quite strong, as words can be activated faster whenever competing candidates can be eliminated by the mismatch of a single segment – a vowel or a consonant. This is to say that segmental information that does not match a matched competitor is quickly eliminated. Soto-Faraco et al. (2001), for example, showed that Spanish listeners listening to fragments as *sardi* that matches *sardina*, were significantly faster in eliminating a competing candidate as *sarda*, from *sardana*, in which both words mismatch by a single vowel. And although it has been argued that listeners resort to segmental information for lexical identification earlier than any other information available (McQueen et al. 1994, Cutler 2005), acoustic cues should not be disregarded. This includes suprasegmental, or prosodic information as stress, which has also proved to have a high contributing effect to speech perception.

Prosodic cues are robust in the identification of words and it can facilitate the process of lexical access whenever segmental information turns out to be unintelligible or ambiguous (Van Heuven 1985). For example, stress is key to disambiguate BP minimal pairs as *HÁbito* "habit" vs. *haBIto* "to live". Given that these words are segmentally equal, the listener is inclined to resort to prosodic information in order to make sense to the word the speaker has tried to transmit. Accordingly, the unstressed sequence *ha* is not the same of *HÁbito*, but of *haBIto*, as the former, in contrast to the latter, the same sequence is marked by a stressed syllable. As a result, stress can help narrow down the search to the correct lexical candidate.

In the last few years, there has been a great array of priming experiments to investigate the contribution of segmental and suprasegmental cues in the activation of a correct word, and the extent to which the absence of each one of these cues is more detrimental to lexical access. In the following subsections we will report some background literature on the importance of segmental and suprasegmental cues on word recognition. Among these, there are experiments involving English and the impact of segmental cues that correlate with stress, and its differences from how stress is cued in Dutch and in BP.

4.2 Stress and word recognition – the case of Dutch listeners

Perceptual correlates of stress can differ across languages, which makes them highly language specific. Dutch and English, for example, are prosodically similar. Both languages are part of the stress rhythm, in that strong syllables (containing full vowels) and weak syllables (containing reduced vowels) appear in opposition to each other. They are also weight-sensitive languages: branching rhymes are stress attracting, which consequently make the stress position vary considerably within a word. However, they both differ with regard to what is considered a heavy syllable: in Dutch, only closed syllables are heavy. The same holds for English, yet long vowels are also heavy (Trommelen & Zonneveld 1999).

Despite the fact that English and Dutch have very similar phonological properties, they differ in the extent to which segmental and suprasegmental cues to stress are used in both languages. Stress in English has phonological and phonetic correlates, for which the former outweighs the latter. As for phonological correlates, this is to say that syllable prominence is identified by the quality features of the vowel: that is, height, backness and rounding. For example, if a syllable has a full vowel as nucleus, this vowel is full in quality (e.g., [æ] is specified as [+low] and [-back]); whereas a syllable that contains a reduced vowel lacks this specification. In the word *bellow* /ˈbɛləʊ/, for example, the vowel in the stressed syllable has full quality, whereas in the unstressed one is reduced to a schwa. The way to verify this phonetically is by the formant patterns (Beckman and Edwards 1994). Thus a stressed syllable in English most always has a full vowel which is longer and louder – that is, more prominent than the adjacent unstressed syllable that has a reduced vowel and it is shorter and lower than its stressed counterpart.

The use of vowel quality is exploited more in English than in Dutch (Cutler 1986; Koster & Cutler 1997; Cooper et al. 2002). Native speakers of English rely more on the segmental contrast between full versus reduced vowels in order to distinguish syllable prominence than that they rely on suprasegmental information. Accordingly, in English suprasegmental information is weaker than segmental information, given the fact that stressed syllables that contain full vowels are usually adjacent to unstressed syllables that contain reduced vowels. Segmental information makes native speakers of English to unmistakably choose for the right candidate in lexical identification, due to the fact that stress will almost always depend on vowel quality. On the one hand, this pervasive characteristic of English facilitates the identification of stressed syllables; on the other hand, speech perception can be inhibited when minimal pairs contain adjacent syllables (stressed x unstressed) with full vowels. For instance, Cutler (1986) showed that words as *forBEAR* and *FORbear*, whose vowels are both fully realized in stressed and unstressed positions, can be taken as homophones and may be only distinguished when contextualised. This is to say that either one of the two words activates words that have relation to both of them. Thus, suprasegmental differences are not exploited for the benefit of lexical identification. This pervasive characteristic of English prosody is supported by the fact that words can still be accessed when there is stress shift and no change in vowel quality. On the contrary, lexical recognition is inhibited should a stressed vowel become reduced or a reduced vowel become full, without change in suprasegmental correlates (Cutler & Clifton 1984).

Analogous experiments have been conducted to Dutch listeners, mostly in order to compare the extent to which Dutch and English listeners differ in the use of prosodic information for lexical identification. Dutch also employs reduced vowels in unstressed syllables; however, the number of words in Dutch that contain full-unstressed vowels (usually words longer than two syllables) is by far larger than in English. [10] In Dutch, a full vowel can very often be found in unstressed positions. For this reason, it has been suggested that Dutch listeners are highly proficient in identifying words by means of suprasegmental information only (Cooper et al. 2002). Accordingly, segmental cues to stress is usually not strong enough, and listeners are mostly left with suprasegmental cues for lexical identification. Recall that, as Sluijter (1995) pointed out, vowel quality is a poor stress correlate in Dutch, and that depending on the word position in a sentence, it can be even weaker than intensity (see fig.1).

Supporting evidence for the above has been provided by a considerable number of experiments involving Dutch speakers. Koster and Cutler 1997, for example, compared the extent to which Dutch listeners make use of segmental and suprasegmental information in lexical access. In a semantic judgement task, participants had to identify monomorphemic items, some of which (i) received the canonical pronunciation (e.g., *CObra* "cobra", *fatSOEN* "decency", *BLUNder* "blunder", *beGIN* "start"); (ii) other forms were altered either in segmental – reduced vowels became full without suprasegmental change (e.g. BLUN*dier*, *bee*GIN) or suprasegmental structure – words that lack reduced vowels, stress shifted to the unstressed vowel and no segmental structure occurred (e.g., *coBRA*, *FAtsoen*); (iii) and the third condition had both, stress location and segmental structures altered. The results revealed that suprasegmental mismatching had a similar effect to that of segmental mismatching, suggesting that Dutch native speakers make use of both cues for lexical access. No significant difference was found for condition (ii), showing that both cues are equally strong for word recognition. Overall, Dutch exploits prosodic features to a great extent, since in this language full vowels can also be found in unstressed syllable position.

In a series of experiments, Cutler & Van Donselaar (2001) investigated whether native speakers of Dutch make the same use of segmental and suprasegmental stress cues in the recognition of words that are segmentally ambiguous. The first experiment showed that suprasegmental cues are

[10] Cooper et al. (2002) is not clear whether they are referring to the absolute or to the relative number of words.

strong enough, in that Dutch listeners can successfully identify a word only by means of one or two syllables presented. For example, participants could successfully identify that unstressed fragments as *lo* belonged to *DOORlopen* "to move along" and not to *doorLOpen* " to finish". Therefore they are able to say if the fragments heard come from a stressed or unstressed syllable.

Moreover, Cutler & Van Donselaar (2001) investigated if Dutch listeners could identify words only by means of stress patterns employing minimal stress pairs as *VOORnaam* "first name" and *voorNAAM* "respectable", in which both words contain syllables with full vowels. The results indicated that the subjects could eliminate word candidates if the stress pattern did not correspond to the prime word. This brings strong evidence that stress is an important cue to lexical activation in Dutch. Accordingly, if stress were not used to disambiguate information, two adjacent syllables of a minimal pair, both containing full vowels, would activate either one or the other choice existent; that is, *VOORnaaam* would activate the noun and the adjective *voorNAAM*. The listener would have then to wait until relevant segmental information became available, or even wait for the sentence context. Recall that this result is different from the one achieved by Cutler (1986), in which English speakers failed to recognize the stressed syllables in minimal pairs that contained two adjacent syllables with full vowels. Thus in English such words would be considered homophones.

Interestingly, Correia et.al (2015) showed that the alternation of full- stressed versus reduced-unstressed vowels are a robust cue to stress perception in European Portuguese (EP). Similar to BP, penultimate stress is the predominant pattern in EP (Cruz-Ferreira 1998). In an ABX discrimination task, EP participants listened to disyllabic and trisyllabic nonsense words, in nuclear (NP) and post-nuclear (PN) conditions that differed only in stress position: e.g., *MIpu/ miPU, DAmitu/ daMItu/ damiTU*. Because vowels of stressed and unstressed syllables were manipulated to the same duration, EP listeners failed to identify stressed syllables only by means of a suprasegmental cues, revealing a degree of stress deafness in EP listeners. This result was further confirmed in a recall task, in which they also employed nonsense words marked by suprasegmental cues only. Again, EP listeners committed more errors in attempting to identify the stressed syllable in both conditions (NP/PN), than in the control group. Thus vowel quality plays a key role in stress perception in EP.

The influence of segmental make-up in the perception of stressed syllables in EP supports the view that acoustic-phonetic prominence of stress can be highly language specific. Our hypothesis that languages with non-predominant stress position have a more prominent prosodic realization would then be dependent on the amount of vowel reduction found in unstressed syllables and whether listeners employ it to identify syllable prominence. This is the case of Dutch. However, for the case of EP and English, segmental, as opposed to suprasegmental information, is crucial for stress perception.

Another research relevant to the present investigation is by van Heuven (1985). He conducted two word recognition experiments: gating and real-time recognition tasks. These were done in order to check the inhibition effect of misplaced stress on word recognition. The items investigated were disyllabic (for the gating) and trisyllabic (for the real-time) low frequency Dutch words, in that all the syllables contained only full vowels. In the gating experiment, half of the disyllabic words had lexical stress on the prefinal syllable and half on the final syllable, in that some of which were pronounced with the correct stress position, whereas some had the pitch accent realized in the incorrect syllable. As for the real-time experiment, three stress positions were possible: the correct and two incorrect stress positions. In both experiments, synthetic speech was also used as to check the effect of correct and incorrect stress without the influence of segmental quality.

Both experiments achieved similar results, showing that stress misplacement inhibits word recognition. Yet, the percentage results showed greater negative effects in words with final and penultimate stresses. This amounts to 34% of recognition scores when the latter pattern is shifted to initial position, while only 25% of the former was stressed on the penultimate syllable. This is an indication that word recognition suffers more when mismatch comes from one of these syllable patterns than when lexical-initial stress is moved to other positions. Van Heuven attributes this difference to the affixation role in Dutch. On the one hand, the addition of a suffix can change the stress position in a word: it can bear the stress itself, or backshift the stress. On the other hand, prefixes are usually stress neutral, and do not cause stress shift to the beginning of a word. We will return to this issue in chapter 6. Interestingly, Dutch listeners had more difficulty in identifying synthesized words realized with incorrect stress than when incorrect stress was realized in the normal version. For Van Heuven, stress information becomes highly important when speech is degraded. Most importantly, under unintelligible conditions, stress produced in a wrong syllable can have a special negative effect in word recognition.

From Van Heuven's hypothesis, we assume that stress becomes highly relevant when the quality of speech is deteriorated "because it is extremely robust against noise and distortion" (2008:56). Thus even though speech quality is not good enough, correct stress realization will help in the search of the correct word. It is however unknown, what the results of such investigations would be if we compare perception of stress realization in related languages, such as Dutch and BP. The assumption is that listening to speech in a foreign "related language is also listening to speech in noise" (Van Heuvan 2008: 56). Thus for the experiment conducted for this thesis, we assume that perception of incorrect stress produced by the Dutch speaker will be more inhibiting than the BP realization of incorrect stress, given the negative effect of stress misplacement in noise. That is, segmental and suprasegmental information of incorrect stress together are highly detrimental to word recognition. In addition, recall that both languages employ duration as the most important acoustic correlate of stress. If acoustic correlates of stress are perceptually more prominent in Dutch than in BP, it is possible that the Dutch L2 BP correct stress realization of BP stimulus words be faster recognized than the L1 BP correct stress realization. If our assumption is confirmed, prosodic information will have an advantage recognition in comparison to segmental mismatch, since the latter deviates from the native listeners' prototype.

The experiments described above bring evidence that stress can accelerate word recognition. By the same token, stress realized in a wrong position can slow down the search and even inhibit word processing alike. Moreover, languages have their own way of identifying syllable prominence. Thus, the expectation is that, when segmental information is stronger than suprasegmental information, the latter has very little effect in lexical activation. In contrast, Dutch seems to supply its listeners with enough acoustic cues for word processing. Although Dutch does have vowel reduction, it is not used to cue stress, leaving Dutch listeners with only suprasegmental cues to explore in lexical identification.

Replication of the experiments described above would most probably achieve very similar results again. The experiments brought strong evidence that segmental cues to stress are largely more exploited in English than in Dutch, even when these two languages are very similar in terms of syllable inventory and weight-sensitiveness. Therefore, it seems evident that, if vowel quality is not employed to cue stress in Dutch, Dutch listeners can indeed outperform English listeners in the perception of word stress if only suprasegmental information is made available. The question that arises is whether Dutch can be considered a language with a more prominent stress realization if so far comparison has been made with English, a language in which suprasegmental cues are not relevant for stress perception. If Dutch can indeed be considered a language with a more prominent stress realization, as function of a various possibilities of stress location within the three-syllable window, it seems reasonable to have it compared to languages in which suprasegmental cues to stress are also the only cues available for stress production and perception such as BP.

If Dutch L2 BP word stress is found to be more perceptually prominent than L1 BP word stress, it will be an indication that acoustic correlates of stress in Dutch are more relevant for word recognition than in BP. And although stress in BP also has a contrastive function such as in Dutch, the regularity of stressing the penultimate pattern may disregard the need to a highly perceptual stressed syllable, since BP listeners may rely more on the default stress position for lexical identification than on prosodic cues. Accordingly, the results can show that, even in languages in which stress has a contrastive function, the perceptual use of prosodic cues to stress can be highly language specific. And the results may depend on how regular syllable patterns can receive primary stress in speech production. Thus, our goal here is to test a language group, i.e., BP listeners, with similar materials produced by speakers of two languages that are metrically distinct (i.e., Dutch and BP), and that may differ in the realization of suprasegmental cues to stress. By doing this, we can directly compare whether the stress realization of one language is more perceptually prominent than stress realization of another related language.

4.3 Stress and word recognition - The case of BP listeners

As we have seen in chapter 3, duration appears to be the strongest correlate of primary stress in BP. And if a phrase is in focus position, the second important correlate is a change in pitch. Similar to Spanish, BP stressed and unstressed vowels usually have the same duration (Meireles et al. 2010). Accordingly, since segmental information does not correlate with unstressed syllables (as these are usually not reduced), the assumption is that BP listeners are able to recognize words by means of prosodic acoustic cues only. However, BP has been underrepresented in the field of stress perception, and the only supporting evidence available at the time of writing has been provided by Consoni et al. (2006). They conducted an investigation on how BP listeners recognize words by means of acoustic stress cues. In the BP lexicon, there exist quite a few words – nouns, adjective and verbs – that are segmentally equal, and some differ only in the last syllable; e.g., *SAbia, saBIa, sabiA* ("wise"/ "past imp. verb know"/ "kind of bird"); *FAbrica, faBRIca, fabriCAR* ("factory"/ "3rd p. sg. verb *produce*"/ "infinitive verb *produce*"). Thus prosodic cues must be key for recognition to disambiguate incoming information when segmental information does not suffice.

In Consoni et al.'s perception experiment, the participants had to listen to the sentence "as palavras são ____,____,____ e jubilou" (The words are ____,____,____ and rejoice.), where two-initial syllable fragments were imbedded in this sentence, and the target fragment was positioned in middle position. After listening to each sentence, they had to mark in a written form, from which word was the fragment they had heard. That is, if the fragments heard were *TRAfi*, *masCA*, *maqui*, the word options were: *MAScara, masCAra, mascaRA,* in which *masCAra* was the correct answer. The two-syllable target fragments varied in their stress patterns, which were WS (penultimate stress), SW (antepenultimate stress) and WW (final stress). The main question to be answered in this experiment was whether BP listeners were able to identify the correct word only by being exposed to the first two syllables for the sequences SW and WS, given that in these sequences there is acoustic prominence present that is able to differentiate the words. Moreover, the key question was whether the participants could identify the correct word in the sequence WW, for which acoustic prominence is absent. Recall that, according to Moraes (1995), final stress is usually perceived by the combination of the two preceding syllables, antepenult and penult, which are very similar in weight. And even when final and penultimate stresses have very similar duration, stress is expected to fall on the final syllable. The table below illustrates the percentages of correct and wrong responses each stress pattern received.

Table 4, from Consoni et al. (2006). Relative and absolute numbers concerning the correct stress identification (diagonal line) vs. incorrect stress identification of syllable patterns.

Stress pattern	SW	WS	WW
SW (antepenult)	486 (92%)	39 (7%)	93 (18%)
WS (penult)	31 (6%)	413 (79%)	148 (28%)
WW (final)	11(2%)	76(14%)	287(54%)

As expected, the WW pattern was the one with greater number of errors. As to check how the acoustic prominence may have influenced the participants' decisions when deciding which syllable bears stress in final-stressed words, the authors conducted an acoustic analysis of duration, F0 and intensity of the syllable fragments. Given the results, the authors attributed lack of significance difference in duration between the first syllables in penultimate and final stressed words (0,08 ms for the first syllable in penultimate stress and 0,07 ms for the same syllable in final-stressed words; in contradistinction to 0,14 ms for the initial syllable in antepenultimate-stressed words).

Consoni et al. claim that the errors could also not be based on vowel duration, otherwise BP native listeners would have guessed the final-stressed words as having antepenultimate stress because of the drop in vowel duration (0,07 ms for the first syllable versus 0,04 ms for the second one in the final syllable pattern). For Delgado - Martins (2002 cited in Consoni), although duration is a consistent correlate in speech production in BP, and although it helps in the perception of correct stress, as speakers can identify initial and medial-stressed words, it is, however, not a sufficient cue for stress perception. Instead, she argues that one should consider the relation between the first two adjacent syllables; that is, the values - vowel duration and intensity, for example. In addition, she hypothesizes that the most frequent stress pattern, i.e., the penultimate, is not marked by a specific robust acoustic cue. As a result, Consoni et al. assume that, for the final-stress case, the participants were biased by the prefinal syllable as it is the most recurrent pattern found (the unmarked pattern) in BP. They also checked for vowel quality, F0 and intensity, but no significant differences were found.

We would like to add our thoughts to Consoni et al.'s explanation for the poor participants' performance in identifying the final-stressed syllable. By being exposed to sequences that are very similar in duration, the BP listeners may have been unable to identify the unstressed nature of both syllables in the presented fragment of which the last syllable was supressed. Van Heuven (1985) reported similar behaviour of Dutch native listeners, also in a gating experiment. Dutch has a considerable number of words stressed on the initial syllable; this may bias listeners to recognize the initial syllable as the default position for stress. In incoming information, Dutch listeners will be biased to initial stress position until the appropriate acoustic information comes at their disposal. Consequently, such strategy would lead to an asymmetrical effect on word recognition, which as a result may guide listeners to recognize stress in the wrong syllable. Based on the preceding, we believe that BP listeners would assume stress on the penultimate syllable, as it is the most recurrent pattern, until they can hear the entire sequence of syllables and guess the correct word. So the first two sequences of short-short syllables can either help the listener to guess the word correctly (stress on the final syllable), or assume the default penultimate pattern, even when the antepenultimate syllable is a bit longer than the penultimate one.

Further, the experimental method and consequently the results obtained by Consoni et al. cast doubt on how accurate BP listeners can be when trying to guess the stressed syllable in word fragments, especially regarding final-stressed words. A gating experiment usually requires that, after listening to word fragments, the listener should also be exposed to the entire word (Van Heuven 1985). For the case of BP, when only two-syllable fragments are presented, and contrary to Consoni et al's argument, duration differences accurately guided the listeners to the correct response. That is, long-short and short-long syllable sequences correspond to antepenultimate and penultimate stresses respectively.

As Consoni et al.'s (2006) result shows, BP listeners are indeed able to recognize which syllable bears the main stress and to associate it to the correct word. They are guided by duration, which is a sufficient cue to stress for both initial- and medial-stressed syllables. Thus, hearing a clear initial or a medial stress inhibits word candidates that are segmentally equal but do not match in prosodic information. On the other hand, not hearing a stress does not provide negative information, i.e. word candidates that are segmentally compatible with the stimulus do not seem to withdraw on the basis of no-stress information that has not been provided yet. Hence, better results on the recognition of final stress would have been achieved had the participants been exposed to the entire gate.

4.4 Summary and research questions

In a nutshell, the investigations about the influence of lexical stress have shown that prosodic information is extremely useful for word recognition. These cues can be the only remaining information at the listener's disposal when segmental structure becomes impaired or is insufficient. By the same token, words that are mis-stressed were shown to delay lexical identification, and some experiments even show that suprasegmental and segmental mismatch inhibit word recognition alike (Soto-Faraco et al. 2001). More importantly, lexical items which are wrongly stressed may not be accessed, reinforcing the importance of stress in intelligibility.

Adding to Dogil and Williams's (1999) investigation, one could infer that the regularity of stressing syllable patterns more equally could be responsible for differences in acoustic correlates when segmental cues are not exhaustively exploited for stress perception. In the present chapter, we have seen that Dutch phonology resembles English and German in the sense that it also has a stressed rhythm: adjacent syllables alternate in strong (full vowel) and weak (reduced vowel), and it is weight-sensitive. However, in contrast to English, Dutch words very often contain full vowels in unstressed syllables. Therefore, segmental information (vowel quality) is perceptually not informative enough in Dutch. Thus Dutch supplies its listeners with the suprasegmental correlates duration, loudness and change in pitch associated to the most prominent syllable (Cooper et al. 2002). Added to this, the even distribution of stress patterns in Dutch shall also guide its speakers in the production and perception of the stressed syllable. As within the three-syllable window, syllables have similar probability to be stressed, the most prominent syllable should stand out from the others by means of robust stress correlates. Therefore, considering incoming speech, suprasegmental information can help Dutch listeners narrow down the search to the correct word candidate.

On the other hand, BP can be compared to Polish and Spanish. BP is a weight-insensitive language, for which the penultimate stress is the unmarked predominant pattern. Thus the regularity of stressing the penultimate syllable may turn phonetic correlates not informative enough, which together with stressed and unstressed syllables that are very similar in length may make stress correlates weak in BP. However, even if BP can be taken as a language with weak stress, it is still a language in which stress has a contrastive function, and prosodic information guides its listeners in the identification of the correct word. As we have seen, Consoni et al. (2006) showed that BP listeners are able to identify words by means of two-syllable fragments that differed in stress position only. From Consoni et al.'s experiment one can readily infer that, if prosodic information helps BP listeners in word recognition, we can also expect that words that are produced with stress on the incorrect syllable should, by the same token, inhibit word recognition.

Accordingly, as we have seen, the pervasive characteristic is that stress in BP is predominantly located in one position, and therefore stress may be phonetically less prominent than in Dutch. Recall that Post da Silveira's (2012) experiment showed that the predominance of medial stress biases BP speakers produce the same position pattern in L2 English. If BP speakers are also guided by the penultimate stress pattern in order to produce stress in L2 English, it is possible that BP listeners are also guided by the same pattern for stress perception. This is to say that words correctly pronounced with penultimate stress can be the ones most recognized; as well as BP speakers listening to antepenultimate and final-stressed words, with stress incorrectly produced on the medial syllable, may also be biased by the default pattern. As a result, it is possible that words produced with incorrect medial stress may be the ones least recognized, as listeners may think they are indeed listening to words with penultimate stress.

If a weight-insensitive language has a weaker phonetic prominence of stress than a weight-sensitive language as Dogil and Williams suggest, it seems reasonable to compare two languages in which suprasegmental cues outweighs segmental cues. BP is similar to Dutch in that listeners can make full use of acoustic prosodic features to lexical access, and experiments have shown that BP and Dutch share the same acoustic stress correlates: duration has been proved the most robust cue in both stress production and perception. Added to this, a noticeable F0 movement marks the accented syllable in both languages, which associated to the stressed syllable in focus position, turns out as a sufficient cue for stress and accent (Moraes 1995; Sluijter 1995). Also, BP is the native language of the writer of this thesis, for which she understand considerably about the stress system of the language. Besides this, there is a huge community of BP speakers living in the Netherlands, for which we could confidently recruit to take part in the experiment.

Evidence of the influence of stress on word recognition in L1 was already given for Romance languages as Spanish (Soto-Faraco et al. 2001); however, the majority of investigations has been conducted on Germanic languages, mainly English (Cutler 1986; Koster & Cutler 1997; Cooper et al 2002), Dutch (Van Heuven 1985, Cutler & Van Donselar 2001) and German (Friedrich 2002). As of yet, it is unknown whether word recognition can be more affected (inhibited) when we consider a second language (L2) stress production being perceived by native speakers of a target language. More specifically, it is unknown the extent to which L1 listeners of a predominantly prefinal stress language, such as BP, recognize words in their own language when these are produced by a L2 speaker of a weight-sensitive language, whose L1 stress system relies mainly on suprasegmental information to cue to stress.

The questions above can be tested by measuring reaction times (RT) of participants' responses in a so-called semantic judgement task. That is, participants make a lexical decision about L1 BP and L2 BP auditory stimuli on visually presented words. Studies have shown that an auditory prime with correct stress, which is lexically related to the visual target, can be faster identified in comparison to the same auditory prime that has stress produced in an incorrect syllable (Koster & Cutler 1997; Cooper et al 2002; Cutler & Van Donselar 2001; see also Cutler et al. 2000 and Cutler, Van Ooijen & Norris 1999 for experiments involving segmental information). A mismatch in the input can reduce activation to the target word. Recognition will be more difficult; i.e., inhibited. We used this method because we can directly compare the extent to which correct stress and stress misplacement produced by the Dutch L2 BP and the L1 PB speakers can constrain lexical access of BP listeners. If it is really the case that Dutch acoustic correlates of word stress are more prominent than that of BP, it is to expect that stress realization of BP words by the Dutch L2 BP speaker is differently perceived by BP listeners. We hypothesize that for the correct stress realization, given that both languages employ duration as the most important cue in production and perception of word stress, it is possible that BP words produced by the Dutch L2 BP speaker be faster recognized than the ones realized by the L1 BP speaker. Whereas incorrect stress patterns produced by the Dutch L2 BP speaker should inhibit word recognition to a greater extent than that produced by the L1 BP speaker. This is because stress produced in wrong position, when associated to differences in segmental structure, is most harmful to word recognition.

Given the literature review, in this study we ask the following research questions: (i) Does wrong stress position inhibit word recognition in BP? (ii) Is there a specific stress pattern that is more affected when correct stress is shifted to a wrong position? (iii) Is stress misplacement of BP words produced by the Dutch L2 BP and by the L1 BP speakers differently perceived by BP listeners? Finally, in order to bring some evidence to Dogil & Williams's (1999) hypothesis the main question of this investigation is: (iv) is correct stress perceptually more prominent in weight-sensitive languages, such as Dutch, than in weight-insensitive languages, such as BP, to BP listeners?

Chapter 5 - The experiment – Semantic judgement task

5.1 Materials

A search of the *Corpus Brasileiro* database (Sardinha et al. 2004) provided us with 72 low frequency BP monomorphemic words (i.e., nouns, adjectives). Only words that are not derived from verbs were used. This was done in order to avoid that subjects recognized a verb instead of the adjective (e.g., *SAbia* "wise"/ *saBIa* "3rd person sing. past perfect verb *know*"). In addition, words that are segmentally equal but differ only suprasegmentally, were also discarded (e.g.: *cameLÔ* "barker" /*caMElo* "camel"). The items were equally divided into three different categories according to stress position; i.e., 24 words with antepenultimate, 24 with penultimate and 24 with final stress. Trisyllabic words were chosen as we believe that it can give us a better picture to which direction – back-shifting of initial stress and front-shifting of non-initial stress – can be more detrimental to word recognition. The list of the words is available at the appendix. Three versions were obtained for each word type: one with no change (correctly pronounced), and two others with stress on a wrong syllable. For example, (i) in the no-change condition all words were uttered in their correct form: e.g.: *ciGAna* "gypsy", *picoLÉ* "ice-cream"; while (ii) *CIgana*/ *PIcole* and (iii) *cigaNA*/*piCOle* were uttered with incorrect stress placement.

A further 72 fillers and 12 practice words were chosen. For the latter, three versions of each stress pattern were also constructed, comprising three different stress positions. All the experimental words and half the practice had a target related in meaning. For example, for *CARcere* the target was *prisão* "jail". The words with incorrect stress also had the same target as the correct versions. As for the fillers, the targets were all unrelated in meaning; thus, *LUcido* "conscious" the prime was *parede* "wall". The experimental words and 72 fillers were recorded by a female native speaker of BP; the same items, in the same number, were recorded by a female native speaker of Dutch, with a sampling frequency of 48.000 Hz. The recordings were conducted in a sound-attenuated room at the UiL OTS Phonetics Laboratory (Utrecht University).

The independent variables (item types) are specified as 3x3, in which these are respectively discriminated as follows: stress type (antepenult, penult and final), and one correct and two incorrect versions of each stress type. All the independent variables are specified in the table below.

Table 5. Independent variables broken down by lexical stress realization and actual stress realization. The green cells correspond to the correct stress position (lexical stress); the remainder cells correspond to the incorrect stress realizations (actual stress).

		Actual stress on		
		1st syl.	2nd syl.	3rd syl.
Lexical stress on	Antepenult (1st syl.)	ÁRvore	arVOre	arvoRE
	Penult (2nd syl.)	CAvalo	caVAlo	cavaLO
	Final (3rd syl.)	MAtine	maTIne	matiNÉ

In turn, the independent variables were blocked into six groups, each consisting of 5 BP native listeners (with exception of one group that had six participants), such that the participants in each group listened to all experimental words only once in different versions. Thus, all independent variables varied between items and between groups; e.g., the item caVAlo, with medial stress, appeared only once in group 1. Latin square design, as this method is called, is used to avoid priming effects; i.e., to prevent that participants recognize the word presented in different versions (Van Heuven 2008: 43). Accordingly, each group listened to 12 correctly stressed words spoken by the L1 BP and 12 correctly stressed words spoken by the L2 BP, distributed over the three stress patterns. In addition, each group listened to 48 words with wrong stress positions produced by the L1 BP, as well as by the L2 BP. For each of the incorrect conditions, the 48 words were also equally distributed over the possibilities of incorrect stresses. Thus, each participant was tested with 72 trials, which in total amounted to 2.232 responses.

5.2 Participants

Participants were 31 native speakers of Brazilian Portuguese, all residing in the Netherlands, with no reported hearing problems. Their age varied from 18 to 52 years old and they were all involved with the Dutch language, using it very regularly. Also, the mean time that they had been living in the Netherlands is 7 years. 14 participants volunteered to participate in the experiment, and 17 of them received a modest contribution from the Utrecht Institute of Linguistics (OTS).

5.3 Procedures

The BP native speakers were tested individually in a quiet room, and the items were presented from a computer Ubuntu LINUX 6 running the ZEP program (Veenker 2015). After a practice session, the participants heard an experimental word – from Beyerdynamic DT250/80 headphones – in one of the three conditions, uttered either by the L1 BP or the L2 BP speaker, and subsequently a visual target appeared on a 17” computer screen. Then they had to decide whether the auditory word and the visual target were related in meaning. They had to signal their decision as fast as possible by pressing YES or NO from a response box, from which the YES button was pressed using the dominant hand. There was a 500 ms interval after each auditory stimulus; subsequently a fixation point (+) appeared for 500 ms, indicating the appearance of the target. The target was displayed for 750 ms, and the participants had 2500 ms to respond, counting from target onset (Lentz & Kager 2014).[11] Participants listened to a maximum of 3 adjacent auditory items of the same type, then a different item type was presented. After each trial, the participants received feedback on the responses on the computer screen. This was presented in Portuguese and varied from *certo* “correct”, *errado* “wrong”, or *muito*

[11] The intervals in ms employed in this experiment were based on a similar experiment (lexical decision task) by Lentz & Kager (2014).

lento “too slow”). Since the experimental words have a target that is related in meaning, the correct responses should always be YES. Each participant was busy with the experiment for approximately 30 minutes, as they also had to fill in a questionnaire on their L1 and L2 language backgrounds.

5.4 Results

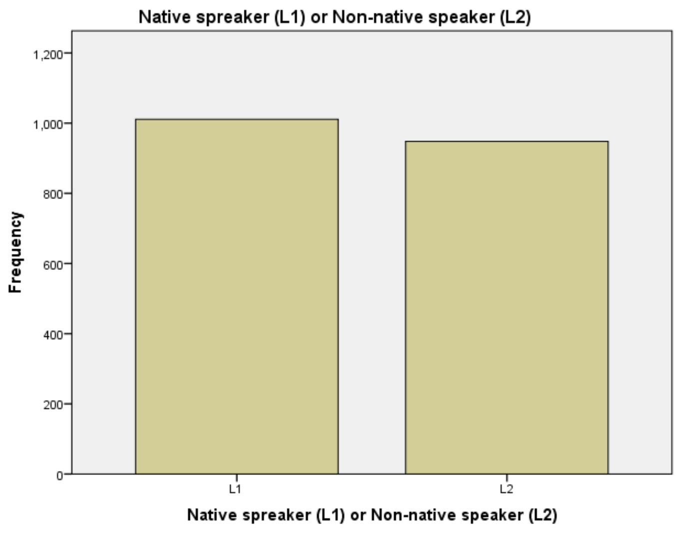
A Liner Mixed Effects Model (Quené & Van den Bergh 2008) was conducted, with random intercepts for participants and items. Only test items were used in the analysis. All the incorrect responses and fillers were excluded. Response times (RTs) were logarithmically transformed (logRT) in order to obtain a normal distribution of the data. The dependent variable is the logRT (RT). The predictors are L1/L2 stimuli and item types - correct and incorrect stress positions.

The analysis showed that there is no significant difference in RTs between the six groups of the Latin-square design $F_{(5, 32)}=1.309$, $p=0.285$; also, no interaction was found between groups and item types $F_{(40, 3626)} = 1.358$, $p=0.79$. Contrary to our hypothesis, the analysis suggests that there is no main effect of L1 versus L2, $F_{(1, 3671)}=0.344$, $p=0.558$, indicating that the participants’ RTs did not differ in the word recognition task between L1 and L2 stimuli. Also, no interaction was found between L1/L2 and item types, $F_{(8, 3659)} = 0.992$, $p=0.441$. There was a significant effect between the 9 items types, $F_{(8, 3658)} = 2.264$, $p=0.023$. The estimates show the significant difference of each item type, having as baseline the final incorrect 2nd syl. item type (e.g., maTIne). These items were the ones slower recognized in comparison to other item types. The following results were significant: antepenult incorrect 3rd syl., p= 0.007; penult correct, p=0.05; penult incorrect 1st syl., p= 0.001; and penult incorrect 3rd syl., p= 0.003, in that these item types were faster recognized than the final incorrect 2nd syl. Mean RTs of each item type and their respective standard deviations (SD) are specified in table 6 below.

Table 6. Mean response RT in milliseconds (ms) and standard deviations (SD) discriminated for each item type (correct and incorrect stresses) for L1 and L2 stimuli.

Item type: correct /incorrect stress	**Mean RT in ms and SD for native BP stimuli (L1)**	**Mean RT in ms and SD for Dutch stimuli of BP (L2)**
Antepenult correct (e.g.,ÁRvore "tree")	3.041 ms (SD 0.011)	3.054 ms (SD 0.011)
Antepenult incorrect 2nd syl. (e.g.,arVOre)	3.047 ms (SD 0.011)	3.048 ms (SD 0.011)
Antepenult incorrect 3rd syl. (e.g.,arvoRE)	3.046 ms (SD 0.011)	3.038 ms (SD 0.011)
Penult correct (e.g.,caVAlo "horse")	3.048 ms (SD 0.011)	3.047 ms (SD 0.011)
Penult incorrect 1st syl. (e.g., CAvalo)	3.048 ms (SD 0.011)	3.029 ms (Sd 0.011)
Penult incorrect 3rd syl. (e.g., cavaLO)	3.037 ms (Sd 0.011)	3.033 ms (SD 0.011)
Final correct (e.g., matiNÉ "party")	3.050 ms (SD 0.011)	3.058 ms (SD 0.011)
Final incorrect 1st syl. (e.g., MAtine)	3.033 ms (SD 0.011)	3.054 ms (SD 0.011)
Final incorrect 2nd syl. (e.g., maTIne)	3.062 ms (SD 0.011)	3.072 ms (SD 0.012)

Figure 4. Mean RTs in ms for L1 and L2 recognized stimulus words.



The percentage analysis of correct (YES) and incorrect (NO) responses, for both L1 and L2 stimuli yielded the following results. From the 2.232 test items, 230 received a NO response, amounting to a total of 10% of error rate. L1 BP stimuli were recognized in 91% of the cases. L2 BP correct stimuli, on the other hand, were recognized in 84% of the cases. The GLMM analysis, having error rates (NO responses) as the dependent variable, shows that there is a main effect of L1/L2, $F_{(2,\ 2.227)}$= 162.02, p< 0.001, indicating that L1 BP stimulus words were significantly more recognized, i.e., had fewer error rates than the L2 BP patterns (see fig. 5). There was also a significant effect for item types, $F_{(8,\ 2.211)}$= 3.890, p< 0.001, for which the final incorrect 2^{nd} syl. was the one with the highest error rate. Having the final incorrect 2^{nd} syl. item type as baseline, the Fixed Coefficients show that the only item types that did not reach significant results were the antepenult incorrect 2^{nd} syl. (p=0.65) and the final incorrect 1^{st} syl. (p=0.88). These two items were the ones that, after the final incorrect 2^{nd} syl. had the highest error rates (see fig. 6).

In addition, Pairwise contrast analysis shows that there is an interaction between L1/L2 stimulus words and final incorrect 2^{nd} syl., p= 0.02, in that L2 BP stimuli realized in this position received higher error rates than the L1 BP counterpart. This result is also confirmed by the RT analysis. Recall that the final incorrect 2^{nd} syl. item type was significantly slower recognized than the overall item types. And although the RT analysis suggests that there is no difference between L1/L2 for this item type, mean RT for the L2 BP stimuli (3.072 ms) is longer than the mean RT for the L1 BP stimuli (3.062 ms). Tables 7 and 8 below present the error scores in percentage for each item type, for both L1 BP and L2 BP stimuli separately.

Table 7. Relative numbers concerning stress pattern errors in a semantic judgment task when stimuli were produced by the L1 speaker. The diagonal green cells correspond to the percentage of errors in correct stressed words (lexical stress). The remainder cells correspond to the error percentage when stress was realized in a wrong syllable (actual stress).

L1		**Actual stress on**		
		1st syllable	**2nd syllable**	**3rd syllable**
Lexical stress on	**Antepenult (1st syl.)**	**10.5%**	**11.3%**	**9.7%**
	Penult (2nd syl.)	**4.9%**	**4%**	**11.4%**
	Final (3rd syl.)	**10.5%**	**12.2%**	**7.3%**

Table 8. Relative numbers concerning stress pattern errors in a semantic judgment task when stimuli were produced by the L2 speaker. The diagonal green cells correspond to the percentage of errors in correct stressed words (lexical stress). The remainder cells correspond to the error percentage when stress was realized in a wrong syllable (actual stress).

L2		**Actual stress on**		
		1st syllable	**2nd syllable**	**3rd syllable**
Lexical stress on	**Antepenult (1st syl.)**	**4%**	**19.4%**	**12,1%**
	Penult (2nd syl.)	**10.5%**	**10.5%**	**14,5%**
	Final (3rd syl.)	**20.2%**	**31.5%**	**12.9%**

Table 9 below presents the mean RT, SD and error rates for each of the independent variables (item types), for both L1 BP and L2 BP stimuli separately. We can see that for 2, 7, 8 and 9 higher mean RTs correspond to higher error rates for the L2 cells, compared to lower mean RTs and lower error rates for the L1 corresponding cells. Opposite patterns are found for 1, 3, 4, 5 and 6, in which higher mean RT is matched to lower error rates when we compare both L1 BP and L2 BP stimuli. On the one hand, lower error rates that match longer mean RTs and vice versa, may be a case of speed-accuracy trade-off, which may indicate strategy causes (e.g., if we think we cannot finish a task because of a limited amount of time, we tend to finish it without being accurate (Fairbrother 2010)) than perceptual causes. On the other hand, such observations could be merely accidental given that the RT analysis suggests that there is no difference in how fast participants recognised the L1 and L2 stimuli; neither were there significant differences between error rates involving the first eight item types. We will return to this issue in section 6.2.

Table 9. Mean response RT in ms, standard deviation (SD) and error rate in percentage for each item types, (correct and incorrect stresses) presented separately for both L1 and L2 stimuli.

Item types correct/incorrect stress	**Mean RT/ SD and error rate for native BP stimuli (L1)**	**Mean RT/ SD and error rate for Dutch stimuli of BP (L2)**
1. Antepenult correct (e.g.,ÁRvore)	3,041 (SD 0.011) 10.5%	3.054 (SD 0.011) 4%
2. Antepenult incorrect 2nd syl. (e.g.,arVOre)	3,047 (SD 0.011) 11.3%	3.048 (SD 0.011) 19.4%
3. Antepenult incorrect 3rd syl. (e.g.,arvoRE)	3,046 (SD 0.011) 9.7%	3.038 (SD 0.011) 12.1%
4. Penult correct (e.g.,caVAlo)	3,048 (SD 0.011) 4%	3.047 (SD 0.011) 10.5%
5. Penult incorrect 1st syl. (e.g., CAvalo)	3,048 (SD 0.011) 4.9%	3.029 (SD 0.011) 10.5%
6. Penult incorrect 3rd syl. (e.g., cavaLO)	3,037 (SD 0.011) 11.4%	3.033 (SD 0.011) 14.5%
7. Final correct (e.g., matiNÉ)	3,050 (SD 0.011) 7.3%	3.058 (SD 0.011) 12.9%
8. Final incorrect 1st syl. (e.g., MAtine)	3,033 (SD 0.011) 10.5%	3.054 (SD 0.011) 20.2%
9. Final incorrect 2nd syl. (e.g., maTIne)	3,062 (SD 0.011) 12.2%	3.072 (SD 0.011) 31.5%

Figure 5. Mean percentage of incorrect responses (NO responses) per speaker stimulus. L1: native speaker and L2 non-native speaker.

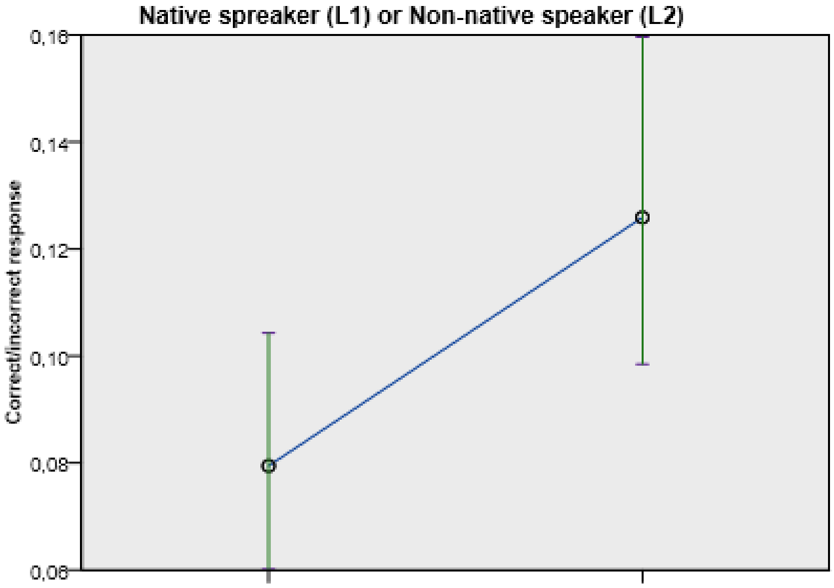
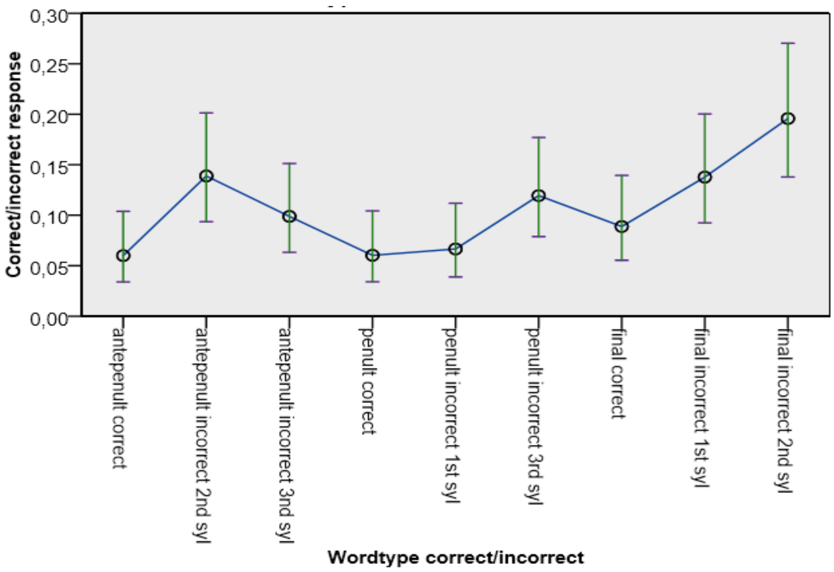


Figure 6. Mean percentage of incorrect responses (NO responses) per item type (word type).



5.5 Discussion

Considering the RT analysis, the results of this study suggest that there is no difference in word recognition between BP stimulus words realized by the Dutch L2 BP and by the L1 BP speakers, indicating that BP prosodic acoustic cues to stress perception are as prominent as in Dutch. In addition, misplacement of prosodic cues to stress does not constrain lexical activation. The only effect of stress misplacement was that of final-stressed words when stress shifts to medial position (final incorrect 2nd syl., e.g.: *picoLE* -> *picCOle* "ice-cream"). As the estimate results show, when final-stressed words have stress shifted to penultimate position, it reaches the highest RTs of all conditions. This outcome was indeed expected. When stress is incorrectly realized in medial position, it becomes detrimental to word recognition, as prosody misleads listeners into believing that they were listening to words with the default-stress position. This result was further confirmed in the GLMM analysis, for which the higher error rates were associated with this stress realization, for which participants found more difficult to recognize the BP stress realization produced by the Dutch L2 BP speaker.

It is, however, not clear why in the RT analysis the antepenult incorrect 3rd syl. and the penultimate patterns were the item types that were recognized faster than the final incorrect 2nd syl. For the latter pattern we can only speculate. As we have seen, penultimate stress is the most frequent pattern in the BP lexicon. Thus it seems reasonable to infer that penultimate-stressed words are the most expected ones and are, therefore, quicker recognized. Yet, while listening to incorrect stress in the penultimate position may deactivate all the candidates in the mental lexicon with non-default stress, incorrectly stressing the initial and final syllables clearly remains unpunished. This may be due to the fact that as initial- and final-lexical stresses are marked patterns in BP – that is, very few words receive antepenultimate and final stresses – misplacing stress to one of these syllables does not seem to block lexical recognition.

The error rate analysis provided us with insightful results on which stimuli are more detrimental to word recognition. Participants found more difficult to recognize the L2 BP realization. This pattern received significantly higher error rates than the L1 BP thereof. In addition, as tables 7 and 8 illustrate, although not significant in comparison to other item types, overall lower error rates were obtained when stress was realized on correct syllables. The L1 BP penult correct stress had the fewest error rates. This was indeed expected since penultimate stress is the default pattern in BP, and should be the most expected and easier to process.

Also, processing wrong-middle stress seems to be a tough task. Front-shifting final-lexical stress into medial position has a highly detrimental effect on word recognition, and significantly more when the stimuli are produced by the Dutch L2 BP speaker. Although not significant, when final stress is wrongly produced on initial position, the error rates for the Dutch L2 BP stimuli are quite higher than the error rates for the L1 BP stimuli (20.2% vs. 10.5% respectively). By the same token, participants found more difficult to recognize the L2 BP penultimate stimuli wrongly produced on initial syllable, in comparison to the L1 BP stimuli of the same stress pattern. Even though the participants were familiar to the Dutch pronunciation, we assume that differences of foreign segments produced by the Dutch speaker of BP may have contributed to higher error rates for the L2 BP stimuli.

Back-shifting antepenultimate-lexical stress to medial position is also harmful to lexical access: 11.3% of the L1 BP stimuli versus 19.4% of the L2 BP stimuli were not recognized. This difference is not significant though, and the error rates are lower than front-shifting stress to the same position. Yet, this is again robust evidence that incorrectly stressing the default-penultimate pattern deceived BP listeners into believing that they came across with a word with penultimate stress. Consequently, they have rejected others competing candidates that have non-medial stress, turning the process of word recognition more difficult than the other incorrect stress patterns.

Chapter 6 - General discussion and conclusions

6.1 General discussion

In this study, we conducted a perceptual investigation to determine whether the stress realization by Dutch learners of BP as L2 is perceptually more prominent than that of BP speakers, for native BP listeners. The motivation for this investigation was based on acoustic-phonetic investigations conducted by Dogil and Williams (1999), in which they showed that languages belonging to different metrical systems might encode phonetic prominence differently. Acoustic measurements of German word stress have shown that this language, which has been classified as weight-sensitive, is marked more prominently than in Polish. The latter is a weight-insensitive language and has a predominant penultimate stress position. Acoustic-phonetic prominence of stress in Polish has been described as weak, as no durational differences can be found between stressed and unstressed syllables.

The hypothesis is that languages that have a more spread distribution of stress patterns, as a function of syllable weight, have stress more prominently marked in the acoustic domain than weight-insensitive languages. In order to check this hypothesis, we conducted a perceptual investigation in which BP listeners were exposed to different stimuli: BP words with correct and incorrect stress positions, produced by a Dutch and a BP speaker. Recall that in both languages, stress has a distinctive function and is cued by suprasegmental information only. Yet they differ in two important aspects: in Dutch, the position of stress is more evenly distributed within the three-syllable window. In contrast, BP stress is predominately penultimate.

Ours predictions were that, overall, BP words with correct stress realized by the Dutch L2 BP speaker would be faster recognized by BP listeners, given the assumed more prominent acoustic stress cues when compared to the L1 BP correct stress realization, overcoming even foreign segmental differences. Secondly, we predicted that such as in other stress languages, in that stress has a contrastive function, BP L1 and L2 BP stress realizations in a wrong syllable would inhibit word recognition to BP listeners. Inhibition would even have a higher negative effect to BP listeners when wrong stress is realized by the Dutch speaker, given segmental and suprasegmental mismatches. Finally, we expected that stress misplacement in the penultimate-syllable position would be the most effected type, since this stress pattern is the most frequent in BP, and therefore the most expected one.

Overall, the RT analysis suggested that there is no difference in perception of stressed syllables between BP stimuli produced by the Dutch L2 BP and by the L1 BP speakers, neither for correct- nor for incorrect-stressed words. There was, however, an effect of final incorrect 2^{nd} syl., which achieved the highest mean RT when compared to other item types. The percentage analysis of errors, on the other hand, showed a significant difference between L1 BP and L2 BP stimuli. The participants found considerably more difficult to recognize words produced by the L2 BP than by the L1 BP speaker. And although no significant difference was found between most L1 BP and L2 BP item types, misplacing lexical stress, in general, generated higher error scores in comparison to correct stress realization (see tables 7 and 8). However, there was again a significant effect of front-shifting final-lexical stress to the default-penultimate position (final incorrect 2nd syl.), for which higher error rate responses were attributed to the L2 stimuli.

Similar results were achieved by Van Heuven (1985), in which he showed the role of stress bias in lexical access in Dutch. In a gating experiment, when disyllabic words with final-stress have stress misplaced to the preceding syllable, 20% lower recognition rates were obtained when all the word fragments had been presented. In a real-time word recognition experiment by the same author, when final-stressed words have stress front-shifted to medial position, only 25% of the words were recognized, versus 34% of recognition score when stress was shifted to initial position. Van Heuven attributes this asymmetry to the affixation role in Dutch. On the one hand, the addition of a suffix can change the stress position in a word: it can bear the stress itself, or backshift the stress (e.g.: spor*TIEF* "sportive" – sportivi*TEIT* "sportsmanship"). On the other hand, prefixes are usually stress neutral, and do not cause stress shift to the beginning of a word (e.g.: af*HAN*kelijk "dependent" – *on*afHANkelijk "independent"). Stressing affixes in BP works in a similar fashion. When suffixes are added, stress may shift backwards (e.g.: *CA*sa "house" – ca*SE*bre "small house"), or the suffix may itself bear the stress, which is then kept after suffixation (fi*NAL* "end" – final*MEN*te "finally"). In contrast, prefixes are always stress neutral, and do not bring about any change to stress location (confiAR "trust"– *des*confiAR "distrust", feLIZ "happy" – *in*feLIZ "unhappy").

Accordingly, front-shifting final-lexical stress is highly detrimental to word recognition since words usually remain with the same stress location after affixation. Furthermore, because penultimate stress is the most prevalent one in BP, it is also the one most perceived and expected. Thus listening to wrong stress in penultimate position may have led the listeners into believing that they were listening to a word with medial stress. This recognition bias is compatible with previous results found in production experiments in that native speakers of BP are guided by the most frequent pattern – i.e., the default penultimate pattern – in their language, in order to produce stress in a foreign language (Post da Silveira 2012).

Based on the above, we can answer our first two research questions: (i) 'Does wrong stress position inhibit word recognition in BP?' BP is a language that also relies on correct prosodic information as to help word processing. Hence, as predicted, the error rate analysis showed that stress placement in wrong position is more difficult to process. Moreover, given the asymmetry found in stress shift, the answer to our second research question '(ii) is there a specific stress pattern that is more affected when correct stress is shifted to a wrong position?' can now be given. Words with lexical stress in the final syllable, incorrectly produced in the default-penultimate position, are the most affected type, probably because front-shifting stress as a function of affixation hardly ever occurs in BP.

According to van Heuven (1985; 1988; 2008), there is no doubt that segmental information is the primary key to lexical access, and when it is associated to correct prosodic information, the process is even accelerated. Prosody becomes a relatively stronger perceptual cue when the segmental quality of speech is impaired. When both sources of information deviate from the normal native listeners' patterns – e.g., incorrect stress placement and segmental mismatch – it is most detrimental to speech recognition.

Evidence from the above was shown in an experiment by Caspers (2010). She investigated the effect of segmental and suprasegmental errors produced by L2 Dutch learners in a native speaker intelligibility, comprehensibility and foreign accent. Dutch L1 native speakers listened to words produced by French and Chinese learners of L2 Dutch. Four different conditions across the words were examined: (i) with segmental and suprasegmental errors; (ii) with a suprasegmental error only; (iii) with a segmental error only, and (iv) with neither segmental nor suprasegmental errors. One of the main tasks of this investigation was that the participants had to write down each word they heard, as to check how intelligible the L2 speakers were. As predicted, test items that had no errors achieved quite a high score: 98% of the words were successfully recognized. Conditions (ii) and (iii) reached very similar scores; i.e., words with suprasegmental errors were 83% recognized in comparison to 77% when the item had a segmental error, where no significant result was found between these two conditions. Words of condition (i) received the lowest intelligible score, which amounted to only 53% of recognition. The conclusion arrived for this experiment was that suprasegmental errors can be as harmful to word recognition as segmental errors. Most importantly, it brought evidence of the negative effect prosodic information can have when added to segmental mismatch.

Similar to Casper's results, in the present thesis the L2 BP stimuli realization had higher error rates in stress mismatch when compared to the L1 BP stimuli realization. Accordingly, the answer to the following research question (iii) is stress misplacement of BP words produced by the Dutch L2 BP and by the L1 BP speakers differently perceived by BP listeners?, can be answered positively. Stress misplacement produced by the Dutch speaker of BP, especially front-shifting of lexical stress inhibits lexical access more than stress misplacement produced by the BP native speaker. Just as predicted by Van Heuven (2008) and shown by Caspers (2010), together segmental and suprasegmental mismatch is highly detrimental to word recognition, since both cues deviate from the native speakers' prototypes.

Concerning our main prediction in this thesis, we hypothesise that if Dutch stress realization of BP stimulus words are more perceptually prominent than that of the BP native speaker, a difference would be found in the correct stress realization. This is due to the fact that both languages employ duration as the most important cue in production and in perception of word stress. The RT results suggests that L1 BP and L2 BP words were equally accessed, giving an indication that prosodic cues to stress in Dutch are as perceptually prominent as in BP. Conversely, the error rate results provide us with a different insight, for which there is a considerable drop in recognition for both correct and incorrect stress concerning the L2 BP realization. In other words, the percentage analysis suggests that the BP native listeners found more difficult to recognize not only incorrect L2 BP stress realization, but also the correct versions thereof. Given the divergent results involving both analyses, we believe that accurate results would have been achieved should segmental effects had been controlled for. The stimulus words employed in the experiment were not manipulated in order to neutralize segmental effects, causing a methodological problem, which may have interfered in the results.

Also, the participants in the experiment described here, in their majority, were quite familiar with the Dutch pronunciation. That is to say that prosodic and segmental differences could have worked to their benefit. Despite this, as experiments have shown (Sebastián-Gallés 2005), we agree that there still remains some level of plasticity that refrains adult learners from achieving accurate perception that can be equally comparable to native-speaker perception. Thus, we infer that segmental differences may have been responsible for impeding native processing of the L2 BP realization, as shown in percentage analysis. We therefore conclude that the answer to our main research question (iv) 'is correct stress perceptually more prominent in weight-sensitive languages, such as Dutch, than in weight-insensitive languages, such as BP, to BP listeners?' that given the methodological pitfall mentioned previously, the experimental method failed to give a reliable answer.

In the present work, the main question we attempted to answer was whether Dutch correct-stress realization, a weight-sensitive language, is perceptually more prominent than that of BP, a weight-insensitive language, to BP listeners. Overall, the percentage analyses showed that BP listeners found the L2 BP Dutch production of BP stimulus words, with both correct and incorrect stress positions, more difficult to be recognized than when these conditions were realized by the L1 BP speaker. For the Dutch correct stress realization, segmental differences may well have been responsible for the highest error rates.

We also investigated the extent to which the L1 BP and the L2 BP wrong stress realizations affected lexical access of BP native listeners. Based on previous research of spoken word recognition, the results presented here go hand in hand with other findings on the role of stress misplacement in language processing, for languages that stress has a distinctive function: Spanish (Soto-Faraco & Sabastián-Gallés 2001) and Dutch (Van Heuven 1985). Accordingly, we predicted that suprasegmental information would also have a strong role in BP. The results could not be different for BP, since as we have seen, Consoni's (2006) investigation provided us with evidence that BP speakers make use of prosodic information in the identification of stressed syllables in word fragments. As a result, the error analysis showed that stress produced in a wrong syllable constrains activation of target words.

We also wanted to know if there was a particular stress pattern in BP that would be more affected by stress shift. According to the results, when final-lexical stress is incorrectly realized in the penultimate position, it is most detrimental to lexical activation. This gives evidence of the affixation phenomenon Van Heuven (1985) similarly reported for Dutch. In both languages, the most prevalent pattern is that stress can be back-shifted when a suffixed is added. Prefixes, however, are usually unstressable, and therefore stress hardly ever is shifted to the beginning of a word. Thus we believe that this behaviour explains why final-stressed words are most affected by stress shift in comparison to the other stress patterns. Front-shifting final-lexical stress led to an asymmetrical perceptual phenomenon, in that participants assumed they were hearing words with penultimate stress. Further, greater effect was even found in BP native listeners' perception of the BP L2 realization of BP stress misplacement, confirming the negative role of segmental and suprasegmental mismatch in word recognition showed in previous experiments (Van Heuven 1985, 1988, 2008; Caspers 2010). Thus when BP words deviate in segmental realization, a higher negative effect in word recognition can be achieved when prosodic information is realized in the incorrect syllable.

6.2 Limitations of the present study and suggestions for future research

In this section, we would like to address some of the limitations of this investigation that may have compromised the results, as well as suggestions for future research.

As we mentioned in the previous section, the BP listeners had already quite some experience with the Dutch language: the mean time of the participants living in the Netherlands is 7 years. Thus it is possible that the amount of L2 exposure may have influenced in the perception of the L2 BP stimuli, and influenced the RT analysis. Escudero & Boersma (2004) showed that second-language learners have full access and full transfer of the language acquisition device. They performed a study involving Spanish native speakers with English as L2 (Southern and Scottish English). Native speakers of Spanish have problems perceiving and producing the English vowels /i:/ and /ɪ/, because these learners are less sensitive to vowel duration. Simulation based on enough input indicated that second-language learners have the capability to build a new category and acquire the full sound distinction of the L2. Although near-native perception does not necessarily result in accurate production (Pater 2004; Kijak 2009), their findings provide some basic evidence that frequency helps the leaning algorithm to acquire the foreign phonological language grammar.

Therefore, we suggest that a followed up research employing reiterant speech (Liberman & Streeter 1978) is highly recommended as to check whether there are indeed differences in stress prominence involving languages of different metrical systems. By doing so, we are able to neutralize foreign segmental interference, and investigate the role of prosody only. In addition, it is important to recruit naïve listeners to participate in the experiment (i.e., native BP listeners who can be tested in Brazil), as to guarantee that their native perception is not influenced by the L2 language. Also the present investigation was quite limited with regards to the number of speaker stimuli; the L2 BP stimuli was recorded by only one Dutch native speaker, as well as the L1 BP stimuli was recorded by only one BP native speaker. Thus, more reliable results can also be achieved if stress realizations are produced by a higher number of Dutch and BP speakers of BP.

Another important aspect to consider is the contradicting results between the RT and the error analysis. Recall that in chapter 5, section 5.4, table 9, low mean RTs for 5 items types were found to have high error rates and vice versa. As to avoid a possible case of speed-accuracy trade-off, a replication of the semantic judgment task experiment conducted for this thesis can be conducted. A suggestion is to reduce the time interval participants have to give the YES or NO answer, after they hear the auditory stimuli and the see visual target word. By imposing more time pressure in the experiment, it is possible that participants give more reliable answers, which are then based on perceptual reasons, and that therefore may match the percentage analysis.

Finally, it would be interesting to conduct a comparable acoustic investigation between the Dutch L2 BP and the L1 BP stimuli. Recall that the two languages investigated here share the same acoustic correlate, which has been proved to cue primary stress successfully; i.e., duration. And for Dutch, spectral balance is also a highly robust cue. If the prediction is that stress if more forcefully produced by Dutch learners in terms of all the acoustic stress parameters, an acoustic comparison between these two languages shall yield significant results. The question that arises is, however, whether a difference in how stress correlates are produced may also lead different stress perception. In addition, as of yet, the contribution of the spectral balance correlate to BP word stress has not been studied. Thus future research can also address the strength of this acoustic correlate in BP. This investigation would also provide a better picture of the phonetics of word stress in BP, for which until the present moment has been underrepresented.

6.3 Conclusions

In conclusion, the present investigation does not give reliable indication of whether weight-insensitive languages, which do not rely on one frequent syllable position to mark word stress, such as Dutch, may be more perceptually prominent than weight-insensitive languages, such as BP, which has a predominant stress position. Hence, the results presented here cannot add to Dogil and Williams's (1999) findings in that weight-sensitive languages have stress more forcefully marked in the acoustic domain than weight-insensitive languages. This thesis showed, however, that despite BP listeners are indeed biased by the default penultimate position for stress perception, in that not only the highest number of correct answers were associated to this stress pattern, but also the highest error rates were associated to the penultimate position, correct prosodic information is key to word recognition. Thus, as other stress languages in which stress has a contrastive function, stress misplacement in BP can inhibit word recognition.

We have also seen that back-shifting initial-lexical stress does not inhibit word recognition in the same extent as front-shifting final-lexical stress. Just as in Dutch (Van Heuven 1985), in BP, prefixes are usually stress neutral, in contrast to suffixes which can shift stress backwards or even bear the stress itself. Finally, the error analysis revealed that the L2 BP stimuli in general inhibit word recognition more than the L1 BP stimuli, to BP listeners. This difference is significantly marked when final-lexical stress, realized by the Dutch speaker of BP, is shifted to medial position. This finding brings extra evidence of the role of segmental mismatch in lexical activation. Thus when segmental information deviates from the native speakers' prototype it can inhibit word recognition. Greater negative effect can be achieved when both cues, segmental and prosodic information, differ from the native speakers' language. Thus, as predicted, prosodic and segmental mismatches have a highly negative effect in word recognition to BP listeners, as L2 BP words were even slower recognized than L1 BP words.

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Appendix A
Linguistic research – Utrecht Institute of Linguistics OTS

Todas as informações contidas neste questionário são confidenciais e serão utilizadas apenas para propósitos científicos.

1. Nome:
2. Idade:
3. Sexo:
4. Qual a sua língua nativa?
5. Em que região do país você cresceu?
6. As pessoas de sua região, incluido você, falam algum dialeto diferente da língua padrão usada no seu país? Qual?
7. Qual a língua nativa de seus pais?
8. Em quais países você já morou? Indique o número de anos em que você viveu em cada lugar.
9. Você fala outras línguas além do português? Se sim, enumere-as na ordem a qual você as aprendeu.
10. Com quantos anos você aprendeu a falar holandês (ou outra segunda língua)?
11. Quanto tempo você passou aprendendo essa segunda língua?
12. Indique a competência linguística em holandês (ou outra segunda língua) escolhendo uma das opções abaixo:

Fala	quase nativo	fluente	bom	médio	ruim
Compreensão	quase nativo	fluente	bom	médio	ruim
Leitura	quase nativo	fluente	bom	médio	ruim
Escrita	quase nativo	fluente	bom	médio	ruim
Vocabulário	quase nativo	fluente	bom	médio	ruim
Gramática	quase nativo	fluente	bom	médio	ruim
Pronuncia	quase nativo	fluente	bom	médio	ruim
Fluência	quase nativo	fluente	bom	médio	ruim

13. Seu contato com pessoas que falam português brasileiro:
    Você normalmente fala português no seu dia-a-dia?
    Quantas horas de TV/ rádio brasileira você assiste por semana?
    Quantas horas por semana você lê em português (livro, jornal)?

14. Seu contato com pessoas que falam holandês (ou outra língua estrangeira):
    Você normalmente fala holandes no seu dia-a-dia?
    Quantas horas de TV/ rádio holandes você assiste por semana?
    Quantas horas por semana você lê em holandes (livro, jornal)?

15. Qual o seu grau de escolaridade?

Appendix B

Antepenultimate CORRECT STRESS	INCORRECT	Target
CRIquete	criQUEte criqueTE	jogo
CARcere	carCEre carceRE	prisão
COmodo	coMOdo comoDO	adequado
CItrico	ciTRIco citriCO	ácido
Halito	haLIto haliTO	bafo
SEtimo	seTImo setiMO	número
CROnica	croNIca croniCA	narrativa
SAtira	SaTIra SatiRA	ironia
Unico	uNIco uniCO	singular
Utero	uTEro uteRO	mulher
MErito	meRIto meriTO	merecido
TImido	tiMIdo timiDO	acanhado
PEssego	peSSEgo pesseGO	fruta
PRINcipe	prinCIpe princiPE	majestade

CEdula	ceDUla ceduLA	dinheiro
CONjuge	conJUge conjuGE	marido
CAlice	caLIce caliCE	taça
BiGAmo	biGAmo bigaMO	casamento
LApide	laPIde lapiDE	pedra
NOmade	noMAde nomaDE	cigano
VANdalo	vanDAlo vandaLO	destruidor
DESpota	desPOta despoTA	tirano
Alibi	aLIbi aliBI	testemunha
MIope	miOpe mioPE	óculos
Penultimate		**Target**
CORRECT STRESS	**INCORRECT**	
iMUne	Imune imuNE	protegido
maDEIxa	MAdeixa madeiXA	cabelo
loROta	LOrota loroTA	mentira
poCHEte	POchete pocheTE	bolsa
PoCILga	POcilga	chiqueiro

	pocilGA	
aSIlo	Asilo asiLO	velho
palMAda	PALmada palmaDA	mão
reCAdo	REcado recaDO	aviso
seDOso	SEdoso sedoSO	macio
ciGArra	CIgarra cigaRRA	inseto
ciLAda	CIlada cilaDA	emboscada
caREta	CAreta careTA	face
laREIra	LAreira lareiRA	fogo
eLEnco	Elenco elenCO	atores
gaLEgo	GAlego galeGO	loiro
graNAda	GRAnada granaDA	explosivo
laVAbo	LAvabo lavaBO	banheiro
esTAca	EStaca estaCA	madeira
cosTUme	COStume costuME	hábito
iAte	Iate iaTE	barco

teCIdo	TEcido teciDO	roupa
vaLIse	VAlise valiSE	maleta
naNIco	NAnico naniCO	pequeno
soTAque	SOtaque sotaQUE	pronuncia

CORRECT STRESS	**INCORRECT**	
cariTO	CArito caRIto	solteira
esquiMO	ESquimo EsquiMO	frio
glaciAL	GLAcial gaCIal	gelo
joviAL	JOvial joVIal	alegre
castiÇAL	CAStiçal casTIçal	vela
efiCAZ	Eficaz eFIcaz	útil
tafeTA	TAfeta taFEta	tecido
matiNE	MAtine maTIne	festa
cabaRE	CAbare caBAre	boate
canaPE	CAnape CaNApe	petisco
pangaRE	PANgare panGAre	cavalo

maraJA	MAraja maRAja	riqueza
jabuTI	JAbuti jaBUti	tartaruga
BacuRI	BAcuri baCUri	garoto
gigoLO	GIgolo goGOlo	cafetão
paleTO	PAleto PaLEto	casaco
javaLI	JAvali jaVAli	animal
comiTE	COmite coMIte	comissão
caraTE	CArate caRAte	luta
corteSÃ	CORtesã corTESã	prostituta
degraDE	DEgrade deGRAde	cor
jacaRE	JAcare jaCAre	reptil
juguLAR	JUgular JuGUlar	veia
capaTAZ	CApataz caPAtaz	peão

<u>Fillers</u>
<u>Antepenultemate stress</u>

Correct antepenultimate stress	**Target**
BALsamo	pacel

BARbaro	tontrole
PANtano	calta
CEtico	vama
ENfase	goca
Exodo	fente
LUcido	paneja
PAlido	xâmera

Incorrect penultimate stress

peSAmes	cadei
inDIce	talete
miMIca	reloto
graFIca	telefone
peNALti	almodafa
chaCAra	droqua
sinDROme	tapor
anGUlo	farrafa

Incorret final stress

arvoRE	zençol
bebaDO	moallha

silaBA	controbe
duviDA	besa
proxiMO	pampada
cereBRO	lachorro
decaDA	clor
maxiMO	patografia

<u>**Penultimate stress**</u>

correct penultimate stress	**Target**
reTRAdo	laixa
poRREte	bopo
meGEra	corritão
paMOnha	vinelo
maCEte	tuvem
poMAda	fabrito
chiCLEte	chuz
carCAça	deia

Incorrect antepenultemate stress

CIdade	blanta
BAnana	neba
BArriga	danela

CArater	fescada
NAvalha	pareve
ORgulho	cavazo
VAsilha	horavo
ZArolho	faba

Incorrect final stress

bizaRRO	tarfo
desfiLE	gorradeira
empaDA	lidro
escuRO	chate
graniZO	lapel
pianO	vato
segunDA	telo
varanDA	bolher

<u>Final stress</u>

correct final stress	**Target**
massaPE	zampú
oriXA	tamra
candonBLE	zolha
triviAl	ginha
reciTAL	morradeira

caniBAL	naneta
vegeTAL	bogo
aveLA	padarço

Incorrect antepenultimate stress

PAternal	gueia
CAracol	lhofa
PREStação	lapavra
CARnaval	mortina
ARtesão	destante
BAcharel	bãosa
CApitão	tivro
MOcoto	larrafa

Incorrect penultimate stress

caTEdral	braia
eLEIçao	tar
esCRItor	cafo
piCOle	tovista
juBIleu	nareira
isopor	sanitelio
liTOral	metra
naTAção	béu

practice items

correct stress	**target**
CAsa	lar
QUAdro	pintura
gelaDEIra	frio
caDERno	livro
coraÇAO	amor
elevaDOR	escada
incorrect stress	
PAlavra	letra
sapaTO	pé
CAfe	pó
BOne	chapeu
Argila	barro
COLchão	cama
fillers	**target (non-word)**
correct stess	
floRESta	bano
hoNESto	responja
incorrect stress	
leNHA	lagodão
balDE	tavalo
piPA	felhado
cabeÇA	zama