EFFECTS OF STRESS AND METRICAL PATTERN ON DURATION PERCEPTION IN SPANISH

Master Thesis Linguistics: The Study of the Language Faculty

Utrecht University

Name: Mariella Márquez Mendoza

Student number: 3512762

August 2011

Supervisor: Dr. Hugo Quené

Second reader: Dr. Sergio Baauw

ACKNOWLEDGMENTS

First of all I want to thank my supervisor Hugo Quené, not only for introducing me into the fascinating world of Phonetics and experimental design, but for his permanent motivation and encouragement. Our interesting discussions have made my love for the Linguistics become greater. Thanks Hugo for sharing bright ideas with me, for all the time you gave me, for asking me to do the wonderful internship under your supervision, and especially thank you for talking with me when I needed it the most.

I also want to thank Eric Reuland, who challenged me with the exciting mysteries of reflexives in Spanish. Eric, you are a source of inspiration. Thank you for your time, patience and lessons you gave me.

Without question I am a very lucky person for living in this amazing country I can call home. The price for all this good is sometimes high, though. I cannot share the day-to-day with my beloved brothers and sisters Juan, Miryam, Gianinna and Alexis. You all give me energy, happiness, hope, and make me feel proud; thank you for being my inspiration. It does not matter that there exists a huge distance between us; your love and energy are always with me. Our dearest mother still lives in each one of you, with the courage and power that all of you have. Thanks mom, for your unconditional love and for giving me my brothers and sisters. Lo doloroso de tu ausencia sólo se puede sobrellevar con la presencia de mis hermanos.

Living far from one’s family can only be motivated by a very powerful reason. I have the most powerful one: love. René, my beloved husband, fills my days with sweetness and shows me everyday the beauty of my new home. Thank you René for your pure and unconditional love, for trusting in my capacity, for supporting me all these years, for being proud of me and for making me laugh when I am worried or sad. You are the best man I know and I am the luckiest woman for sharing my life with you. Liefste, ik hou van jou.

Gracias Dios, mi querida madre María, y mis ángeles de la guarda, por acudir en mi ayuda cada vez que los necesito.

CONTENTS

ABSTRACT

This thesis focuses on prosodic expectations, especially on the research done by Zheng & Pierrehumbert (2010). They lengthened syllables of meaningful English sentences and investigated the conditions in which the lengthening was better detected. Target syllables varied in metrical stress, metrical pattern, serial position and speech rate. Detection was better for strong syllables in all metrical patterns, serial positions and speech rates. The trochaic metrical pattern yielded a higher detection rate than the other two patterns. Zheng & Pierrehumbert claim that their findings confirm the Attentional Bounce Hypothesis (Pitt & Samuel 1990). According to this hypothesis, listeners use the sequencing of strong and weak syllables to predict where stress will fall. Interestingly, the influence of meter was contrary to the findings by Quené & Port (2005) for English, in which the effect of metrical expectancy was not confirmed.

The present thesis aimed to replicate the study by Zheng & Pierrehumbert for Spanish. This language has a different metrical stress, with stress mostly on the penultimate syllable instead of on the initial syllable (Sebastián-Gallés & Costa 1997), thus making it presumable that (the trochaic) meter would not have an effect on lengthening detection. An experiment was conducted with native speakers of Castilian Spanish. Results indicated that, even though present, the effect of stress is weaker in Spanish than in English. Metrical pattern has a large effect on duration perception: the dactylic pattern facilitates perception in Spanish, and not the trochaic pattern, which had the highest hit rates in English. Reaction times indicated that serial position is the relevant factor for faster responses, with faster reaction times at the end of the stimuli. The influence of the attentional bounce hypothesis is discussed.

I INTRODUCTION

In this work, stress and metrical pattern play a central role. One of the theoretical approaches bringing both factors together is the Attentional Bounce Hypothesis. The fist study developing on this hypothesis was by Shields, McHugh & Martin (1974). They discuss the rhythmic theory developed by Martin (1972), who hypothesized that there are rhythmic patterns in which some elements are accented, whereas others are not. A rhythmic pattern is temporally redundant, so that once early accents are heard, the location of later accents can be predicted in time. This perceptual mechanism allows for the focusing of attention on the elements of the speech sequence receiving accent. Shields et al. (1974) tested the hypothesis that the temporal redundancy in the speech sequence is used by the perceptual mechanism. The prediction was that the listener anticipates on the accented syllables, which are targets during perception. Consequently, the reaction times should be faster to targets in accented syllables than to targets in unaccented syllables.

In their main experiment, Shields et al. (1974) presented subjects with sentences containing a target phoneme in accented and unaccented syllables and their task was to press a button when hearing the phoneme. In the control experiment, the words containing the target phoneme had been embedded in a string of nonsense words. Reaction times to accented targets were expected to be faster than for unaccented targets, and responses in the sentence context were expected to be faster than responses in the control experiment. In the main experiment the prediction was confirmed, whereas in the control experiment the differences in reaction times to accented and unaccented target phonemes were not significant. These results suggested that listeners use the rhythmic pattern of speech to anticipate accented targets in the speech sequence.

The results found by Shields et al. (1974) were according to Pitt & Samuel (1990) not conclusive, since the processing of nonwords used as targets was not yet understood and the results could be attributable to uncontrolled acoustic factors. In their study, Pitt & Samuel (1990) attempted to control for acoustic variation. They introduced the term attentional bounce hypothesis, thought of as moving from one stressed syllable to the next. The temporal regularity from one stressed syllable to the next may provide a stable structure that the processing system can capitalize on by predicting the future occurrence of stressed syllables.

Pitt & Samuel (1990) ran 3 experiments. Experiment 1 was a replication and extension of Shields et al. (1974). They found no reaction time differences between the predicted-stress and the predicted-nonstress conditions, suggesting that the findings in Shields et al. (1974) were due to acoustic factors. Experiment 2 tested the attentional bounce hypothesis by using a stronger manipulation of rhythmic stress. The same neutral target words from Experiment 1 were embedded in sequences of two-syllable words (nontargets). They expected that the sequences of same-stress nontarget words preceding the target word would induce rhythmic expectancies. Results supported the attentional bounce hypothesis, but as Pitt & Samuel (1990) observe, factors other than the rhythm of stressed syllables could be responsible, such as the strategy to increasingly expect a target as more and more nontarget words occurred prior to the target word. Experiment 3 was conducted as a control study of Experiment 2, by eliminating the rhythm of the nontarget words preceding the target. Reaction times obtained in Experiment 3 were similar to those found in the predicted-nonstress condition in Experiment 2. This outcome favoured the interpretation that rhythmic expectancies develop in speech perception and result in the allocation of more attention to stressed than to unstressed syllables.

Quené & Port (2005) observed that Pitt & Samuel (1990) controlled the contents of their speech material by systematically varying what was heard in the stimuli. This factor is the metrical expectancy of the listener and the metrical sequencing of strong and weak syllables. Importantly, there was no control over when the strong syllables were heard, i.e. the actual timing of the speech context. Listeners could not make expectations of when strong syllables would occur due to the irregular timing and great variation in inter-word time intervals. Timing regularity was therefore not controlled in Pitt & Samuel (1990). Quené & Port (2005) claimed that the timing patterns in the preceding sentence context lead to a timing or rhythmic expectancy that contributes to the perception of stress shift. This claim is supported by the Dynamic Attending Theory (Jones 1976, 1990). There is an oscillator's attentional pulse that can track slow changes in inter-onset intervals but not fast changes.

Considering that there were already studies supporting the influence of attentional rhythms, but with no control over stimulus timing, and other studies controlling stimulus timing but using non-speech materials, Quené & Port (2005) investigated the effect of stimulus timing on the perception of speech, using the phoneme monitoring paradigm (Quené & Port 2005: 4). Timing regularity was the first factor of their study. Additionally, their experiment manipulated the metrical expectancy of the word sequences. Results showed a main effect of timing regularity on spoken-word perception, providing support for the Dynamic Attending Theory (Jones 1976, 1990), the perceptual-isochrony hypothesis (Lehiste 1980) and PolySP model (Hawkins 2003). However, no effect of metrical expectancy was observed. This means that, for spoken-word perception, it does not matter whether the stress pattern of the target word is the same or different from the preceding words in a list. These results were confirmed in Quené & Port (2008) for Dutch.

My internship was based on Quené & Port (2005). It investigated the effects of timing regularity and metrical expectancy in Spanish, a language with a different stress pattern than English and Dutch. Results indicated that metrical expectancy had no effect on the perception of spoken words, while timing regularity contributes to spoken-word perception.

A recent study related to the points discussed above is Zheng & Pierrehumbert (2010, from now on: Z&P). They addressed how prosodic expectations affect perceptual discrimination. They made use of six-syllable sentences in three metrical patterns: trochaic, iambic and dactylic, at two speech rates, quick and slow. The rhythm was perturbed by the lengthening of one syllable. Presumably, listeners would induce the metrical pattern based on the metrical structure of the sentences. The study investigated whether or not the listeners could detect the lengthening, and whether lengthening of prosodically prominent syllables had a positive effect on listener's ability to detect the lengthening.

Overall, Z&P adopt the attentional bounce hypothesis. Based on this hypothesis, Z&P claimed that listeners would use the metrical sequencing of strong and weak syllables in the speech, to predict where stress will fall. Considering that attention is directed to stressed syllables, they predicted that lengthening is better identified when it occurs on metrically strong syllables than on metrically weak ones. Their hypothesis was confirmed. The most important outcome was that stress indeed had a large effect. Lengthening occurring on strong syllables was better detected than lengthening occurring on weak syllables. Additionally, metrical pattern had an important effect, with higher detection rates for the trochaic meter than for the non-trochaic meters. Also serial position had an effect, especially in non-trochaic patterns, where weak syllables near the end of the sentence showed better detection rates than the same type of syllable in the middle of the utterance. Finally, the slow speech rate, compared to the quick speech rate, increased the detection rate.

There are two important issues discussed by Z&P which must be pointed out. The first one is the influence of stress and the second one is the influence that metrical pattern had on lengthening detection. As for the first point, they claim that the attentional bounce hypothesis explains why lengthening on strong syllables was better detected. Metrical expectations, they argue, were induced by the strong rhythmic patterns of the stimuli. The ability of the listeners to track rhythm is claimed to reflect a long-term exposure to the stressed patterns of English.

As for the second point, Z&P found that the trochaic pattern produced better detection rates than the non-trochaic patterns. Z&P argue that one explanation is that the trochaic pattern is predominant in the English language, and being so entrenched, it freed attentional resources to concentrate on the detection task. This outcome is contrary to Quené & Port (2005), in which metrical expectancy had no effect. Z&P (2010) argue that the reason why Quené & Port (2005) found no significant effect, could rely on the materials used. Word lists, as used by Quené &Port, may not activate metrical expectations, while meaningful sentences (as Z&P used) would.[1]

The present thesis aims to replicate the study by Z&P (2010) using Spanish as target language. First, we want to investigate the effect of stress on duration perception. This will be done by lengthening target syllables. Additionally, we want to know if there is an effect of metrical expectancy, since the studies by Quené & Port (2005) and Z&P (2010) led to different conclusions. Further, the experimental design will manipulate the

---

[1] Z&P did not control timing regularity (inter-stress intervals). However, they evaluated the possibility that the trochaic pattern in their study might have been advantaged by regularity in the inter-stress intervals. They compared the trochaic with the iambic patterns, and concluded that the intervals were not different; therefore, they conclude, rhythmic expectations appear not to be the cause for the better detection in the trochaic pattern.

serial position of the targets, allowing to investigate the effect of serial position on duration perception. Finally, we want to answer if speech rate influences duration perception. The study will consider six factors. The factors are stress, lengthening, metrical pattern, speech rate, serial position and vowel type.

The hypotheses are that strong syllables should be better identified than weak syllables, in all patterns, as found by Z&P (2010). Moreover, metrical expectancy in Spanish should have no effect or a smaller effect than in English. Detection rates for the trochaic pattern are not expected to be better than detection rates for the non-trochaic patterns. This hypothesis is based on the fact that the trochaic pattern in Spanish is not prevalent, as is in English. In Spanish, most words are stressed on the penultimate syllable [2](Sebastián-Gallés & Costa 1997). It is not clear to what degree Spanish speakers make use of metrical information to segment the speech signal. Besides, unlike English, Spanish does not have vowel reduction, that is, the same vowels can be either stressed or unstressed. For these reasons, the effect of metrical expectancy is predicted to be smaller than in English.

Moreover, we hypothesize that the slow speech rate should have a positive effect on duration perception. Lengthening occurring on target syllables at the slow speech rate should be better identified than the same amount of lengthening at the quick speech rate. In addition, we hypothesize that lengthening factor has a positive effect on duration perception. Duration perception should be facilitated by high lengthening factors and hindered by low lengthening factors. Finally, we hypothesize that serial position has an effect on duration perception. Considering that words in Spanish are mostly stressed on the penultimate syllable, we predict that lengthening on a target syllable occupying the 5th position (in the sequence of 6, thus where the target syllable is the penultimate of a word), will be better detected than lengthening occurring in the 3rd and 4th positions.

[2] However, a dysillabic word, stressed on the penultimate syllable, can also result in a trochaic word.

II METHOD

II.1 Materials

Following Z&P, this study used sentences with regular metrical patterns to induce strong expectations of where prominent syllables would occur. The factors considered in the experimental design are explained below.

Metrical patterns. The materials consisted of meaningful six-syllable sentences, falling into three metrical patterns.

- Dactylic (SWWSWW), where the first and fourth syllables in the sentence are strong while the others are weak.
- Trochaic (SWSWSW), where the first, third and fifth syllables in the sentence are strong while the others are weak.
- Iambic (WSWSWS), where the second, fourth and sixth syllables in the sentence are strong while the others are weak.

Z&P (2010) would expect better detection rates for stressed syllables. Therefore, in the fourth syllable in the dactylic pattern, in the third and fifth syllables in the trochaic pattern and in the fourth syllable in the iambic pattern.

Serial position of target syllables. Target syllables occupied the third, fourth or fifth position in the sentence. This way, the effect of utterance boundaries on syllabic duration was controlled. On top of that, all target syllables were in word-final position in order to control for the possible effects of word-final lengthening.

Important to note is that in the dactylic metrical pattern there were no occurrences of target syllables in the fifth position, since the duration of the target syllables in this pattern and position was greater than the duration of target syllables in other serial positions.

Vowel types. In Z&P (2010) four vowel types occurred in the target syllables: [a], [i], [u] and [au]. In the present study this vowel repertory could not be maintained, since the vowel [au] does not exist in Spanish. Initially, the five Spanish vowels [a], [e], [i], [o] and [u] were planned to be used as targets; however, since an experimental design considering the five vowels would be too extensive and the duration of the test too long, it was decided to use only three vowel types as targets: [a], [i], [u].

All stimuli sentences can be found in Appendix I. Some example sentences with intonational patterns in different conditions are:

- *Toma mi brújula* 'Take my compass' (dactylic, third serial position, target [i]).
- *José está feliz* 'José is happy' (iambic, fourth serial position, target [a]).
- *Ellos aman su voz* 'They love his/her voice' (trochaic, fifth serial position, target [u]).

Speech rate. All stimuli were recorded at two speech rates: slow and quick. Similar to Z&P (2010), the absolute duration of weak target syllables at the slow speech rate was comparable to that of the strong target syllables at the quick speech rate. This comparable duration makes it possible to examine the interaction of rate (slow vs. quick) and prominence (weak vs. strong), eliminating absolute duration as a causal factor.

Normal distribution. Before comparing the durations of target syllables, we must check that there is a normal distribution. If the distribution in each group of 9 target syllables per metrical pattern and serial position would not be normal, we could consider taking the median instead of the average duration for our comparisons.

For all 16 groups of target syllables (broken down by speech rate, metrical pattern and serial position), tests of normality were conducted. With the exception of the target syllables in the 4th position of the trochaic pattern in the slow speech rate, the duration of the syllables in all groups have a normal distribution according to Shapiro-Wilk's tests of normality, with some outliers.

Table 1 shows the durational properties of the syllables at both rates. The average duration of strong target syllables at the quick speech rate is 163 ms, and the average duration of weak target syllables at the slow speech rate is 162 ms.

Table 1. Durational properties of strong and weak syllables (ms) at slow and quick speech rate.

	Quick-weak	Quick-strong	Slow-weak	Slow-strong
Min	66	73	111	104
Max	247	269	256	398
Average	131	163	162	245

Nevertheless, for each serial position taken separately, the average duration of strong syllables at the quick speech rate is not comparable to the average duration of weak syllables at the slow speech rate.

Since the relevant durational properties of target syllables are not comparable per serial position, we must further analyze the durational properties of target syllables by looking at the metrical pattern, taken separately. Let us begin with the trochaic pattern in Table 2.

Table 2. Durational properties of strong and weak syllables (ms) at slow and quick speech rate for the trochaic pattern.

	Quick-weak	Quick-strong	Slow-weak	Slow-strong
Position:	(4)	(3, 5)	(4)	(3, 5)
Min	66	73	116	104
Max	153	200	218	390
Average	120	137	154	214

As we see, although the average duration of syllables in the conditions quick-strong and slow-weak is not entirely comparable, the difference between both is not great.

Table 3 contains the information for the iambic pattern. This pattern shows the same behaviour as the trochaic pattern: the relevant average durations are still not comparable, but the difference is not great.

Table 3. Durational properties of strong and weak syllables (ms) at slow and quick speech rate for the iambic pattern.

	Quick-weak	Quick-strong	Slow-weak	Slow-strong
Position:	(3, 5)	(4)	(3, 5)	(4)
Min	85	81	136	134
Max	167	192	222	352
Average	126	150	164	243

Finally, the durational properties of syllables for the dactylic pattern are shown in Table 4. This table shows that in the dactylic pattern, especially the target syllables in the 4th serial position have a long duration. In both speech rates the duration in the 4th serial position is much greater than the duration of the (weak) 3rd target syllable at the slow speech rate.

Table 4. Durational properties of strong and weak syllables (ms) at slow and quick speech rate for the dactylic pattern.

	Quick-weak	Quick-strong	Slow-weak	Slow-strong
Position:	(3)	(4)	(3)	(4)
Min	80	131	111	204
Max	247	281	256	398
Average	150	225	165	309

Summarizing, the greatest deviance in the average durations of target syllables is found in the dactylic pattern. The duration of this target in the 4th serial position is much greater than the duration of the target in the 3rd serial position.

Recordings. All stimuli sentences were written down and recorded first by the author, initially at a slow speech rate and at a quick speech rate afterwards. These recordings were not intended to be the definitive materials for the experiment, but would only be used as guide for the speaker, in order for him to differentiate the slow and the quick speech rates.

The definitive recordings were produced by a male native speaker of Castilian Spanish, from Salamanca. Recordings were made in the phonetics lab of UiL OTS. First, the speaker recorded the stimuli at the slow speech rate and after that at the quick speech rate. The author followed the recordings and noted the sentences that were not clear enough, so that these could be recorded again. The digital recording was made with Audacity, mono sound, with a sampling rate of 48000 Hz. Recordings took place in one session.

Next, all sentences were saved in separate files. In Praat, the target syllable in each stimulus sentence was annotated. Recordings were manipulated using a Praat script (see Appendix II), to lengthen the target syllables by five equal steps: 14%, 21%, 28%, 35% and 42%.

II.2 Participants

Participants were 30 monolingual native speakers of Castilian Spanish. Most of them were students at the High Technical School of Telecommunication Engineering of the Technical University of Madrid. They were paid €15 for participating in this experiment.

II.3 Procedure

The experiment took place in the laboratory of the Speech Technology Group of the Technical University of Madrid.

Subjects were told that they were participating in an experiment on speech perception and that they would hear pairs of sentences with exactly the same lexical content, except that one syllable in the second sentence might or might not be lengthened. They had to decide whether the second sentence was the same or different from the first sentence.

There were 72 different stimulus sentences: 3 metrical patterns x 3 vowels x 3 target locations (with the exception of the dactylic pattern, which had only 2 target locations) x 3 instances per vowel. On top of that, there were 6 durational variants of each stimulus x 2 speech rates. In total, the design involved 864 distinct stimulus tokens. In addition, there were 20 practice items (see Appendix III).

The task was an AX forced-choice task with the base stimulus always in the A position and the test stimulus always in the X position. Each listener heard the same 864 pairs of sentences, in a randomized order, i.e. the order changed every time the experiment was run. The experiment was segmented into four blocks, each consisting of 216 pairs of sentences. The first and third blocks consisted of pairs of sentences at the slow speech rate while the second and fourth blocks consisted of sentences at the quick speech rate.

Each participant was tested individually in a quiet room. Listeners were seated with a laptop screen in front of them and the speech material was presented over closed headphones. They had a button box under their dominant hand. The button box had two buttons. Also the laptop screen in front of the subject had two buttons, labelled "*igual*" (same) and "*diferente*" (different) or "*diferente*" and "*igual*". The order of the labels was randomized: if participant 1 got the label order *igual/diferente*, then participant 2 got the label order *diferente/igual*. There were two experimental laptops available. In Appendix IV information about the participants tested on each laptop (1 and 2) is given.

Each block was preceded by a set of 5 practice items with feedback (see Appendix III). The practice items included two examples of sentence pairs with no lengthening and three examples of sentence pairs with different lengthening factors, metrical patterns, vowel types and serial positions[3]. Subjects were instructed to indicate their choices by pressing a button as quickly as possible. If the labels on the laptop screen were given in the order *igual/diferente*, and the answer was *igual*, then the subject had to press the left button; for the answer *diferente*, the subject had to press the right button. After the practice session, subjects could ask for clarification if necessary.

The actual test block was taken with no feedback provided. During the whole session there was a counter, which indicated the number of pairs of sentences remaining in a block.

[3] This is a difference with respect to Z&P (2010), who only used lengthening 42% for the manipulation of practice items.

Each item consisted of a pair of sentences, preceded by a sinewave beep and a 1,000-ms silent interval. Reaction times were computed during the experiment, using the button pressing event. This is a difference with respect to the experimental design by Z&P (2010), who only registered the correct or incorrect responses.

After each item, there was a 2,000-ms time window for responses, followed by a 750-ms 'dead' interval before the next item. Total time of a test session was about 75 min.

III RESULTS

In this experiment there were 30 participants. Each participant gave 864 responses; therefore there were in total 25920 responses. Recall that the task was to answer if the second sentence was exactly the same or was different from the first sentence.
In general, participants gave more ‘same’ answers than ‘different’ answers:

Table 5. Responses given by participants

Response ‘same’	Response ‘different’	Missing
61,0% (15807)	38,6 % (10015)	0,4% (98)

This result points out a bias: participants were biased to find no difference between pairs of sentences, although there were actually more different than same pairs of sentences (83% ‘different’ vs. 17% ‘same’ pairs of sentences). Almost half of the responses were correct, as table 6 shows.

Table 6. Correct responses, incorrect responses and no responses

Correct responses	Incorrect responses	Missing
49,5% (12819)	50,1% (13003)	0,4% (98)

In Z&P (2010) only the hit rates (percentage of correct responses) were reported. In the present study, in addition to the hit rates, the reaction times were also registered. In this section, the results for Spanish regarding the hit rates will first be presented, and after that the reaction times will be discussed. In chapter IV we come back with a comparison between the results for Spanish and English.

Statistical analyses of the detection rates were complex because of the dependency among meter, serial position and stress, that is the metrical pattern and serial position completely determine the stress, as also indicated by Z&P (2010). Moreover, the analysis of reaction times is difficult because the number of correct responses per participant per condition was unequal. Due to these complications in the data, the complete report has not been included; only the descriptive statistics have been reported.

Nevertheless, the results of the descriptive statistics have been verified with mixed effects models, which confirm the outcomes of the descriptive statistics. Because of the high complexity of these models, which is outside of the scope of this thesis, these will not be reported.

III.1 The hit rates

We will start with an explorative analysis of the main factors in the experiment.

Stress. Table 7 contains the percentage of correct answers, broken down by strong and weak syllables. This table shows that stress had a positive influence on detection rates. In general, lengthening on strong syllables was better identified than lengthening on weak syllables.

Table 7. Hit rates and stress

	Strong syllables	Weak syllables
Correct	53,9% (6985)	45,0% (5834)
Incorrect	45,7% (5928)	54,6% (7075)
Missing	0,4% (47)	0,4% (51)
Total	100% (12960)	100% (12960)

Lengthening. There is a clear trend: the greater the lengthening factor, the better the participants identified the second sentence as different from the first one. Table 8 shows that the baseline comparison had the greatest amount of correct responses. When a syllable of the second sentence had been lengthened, participants gave many incorrect answers. Only for lengthening factor 35% and higher, subjects gave more correct answers than incorrect answers.

Table 8. Hit rates and lengthening factor

	Baseline (0%)	Factor 14%	Factor 21%	Factor 28%	Factor 35%	Factor 42%
Correct	82,15 %	24,70 %	32,48 %	42,20 %	51,78 %	63,43 %
Incorrect	17,25 %	74,81 %	67,31 %	57,52 %	47,80 %	36,30 %
Missing	0,60 %	0,49 %	0,21 %	0,28 %	0,42 %	0,27 %

In conclusion, the degree of lengthening had a positive effect on lengthening detection.

Metrical pattern. Overall, the best discrimination was with the dactylic pattern. In this pattern, participants gave a greater amount of correct answers than for the trochaic and iambic patterns; in these latter two patterns the percentage of incorrect answers was even greater than the percentage of correct answers.

Table 9. Hit rates and metrical pattern

	Dactylic pattern	Iambic pattern	Trochaic pattern
Correct	58,0% (3764)	49,1% (4773)	44,1% (4282)
Incorrect	41,6% (2693)	50.5% (4910)	55,5% (5400)
Missing	0,4% (23)	0,4% (37)	0,4% (38)
Total	100% (6480)	100% (9720)	100% (9720)

The iambic pattern was the second best to discriminate. Apparently, the trochaic pattern is the most difficult.

Serial position. Table 10 shows the hit rates per serial position. Serial position 4 has the most correct answers. Recall that serial position 5 has fewer items, since it was not used in the dactylic pattern.

The reason why lengthening in position 4 seems to be easier to discriminate, can be that in both the iambic as in the dactylic patterns, the syllable in position 4 is stressed and as shown above, stressed syllables facilitated lengthening detection. Only in the trochaic pattern the 4th syllable is not stressed, and the trochaic pattern benefits perception less than the non-trochaic patterns.

Table 10. Hit rates and serial position

	Serial position 3	Serial position 4	Serial position 5
Correct	45,6% (4435)	54,7% (5315)	47,4% (3069)
Incorrect	54,0% (5248)	45,0% (4374)	52.1% (3381)
Missing	0,4% (37)	0,3% (31)	0,5% (30)
total	100% (9720)	100% (9720)	100% (6480)

Vowel. Table 11 shows the hit rates per target vowel. The vowel /i/ had the most correct answers, which is a rather unexpected result.

Table11. Hit rates and vowel types

	/a/	/i/	/u/
Correct	47,9% (4135)	53,4% (4615)	47,1% (4069)
Incorrect	51, 7% (4470)	46,2% (3990)	52,6% (4543)
Missing	0,4% (35)	0,4% (35)	0,3% (28)
Total	100% (8640)	100% (8640)	100% (8640)

Speech rate. Table 12 shows that the slow speech rate had more than 50% of correct answers, more than the quick speech rate did.

Table 12. Hit rates and speech rate

	Slow speech rate	Quick speech rate
Correct	51,0% (6610)	47,9% (6209)
Incorrect	48,6% (6304)	51,7% (6699)
Missing	0,4% (46)	0,40% (52)
Total	100% (12960)	100% (12960)

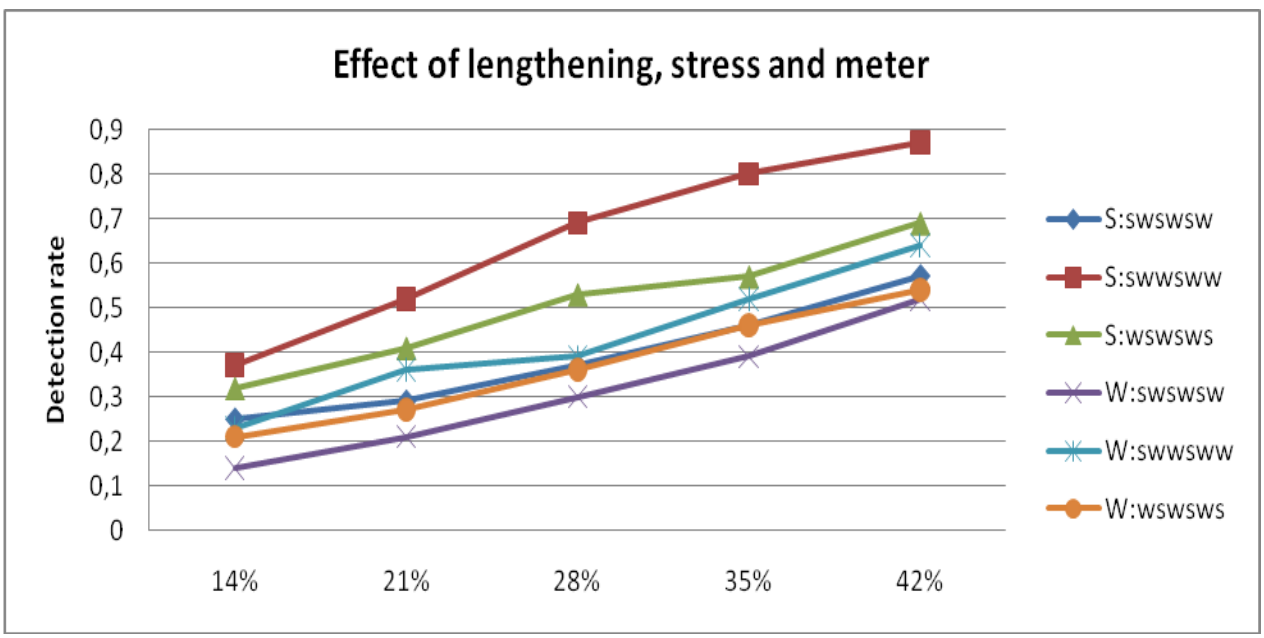
Nevertheless, the difference in hit rates between both speech rates was rather small.

Summarizing, lengthening on strong syllables was better detected than on weak syllables, higher lengthening factors had a positive effect on lengthening detection, lengthening on the dactylic pattern was better detected than in the trochaic and iambic patterns, serial position 4 facilitated detection lengthening, target vowel /i/ had the most correct answers, and lengthening at the slow speech rate was better detected than lengthening at the quick speech rate.

III.1.1 Effect of lengthening, stress and meter

In the figure below, we see how Spanish behaved regarding lengthening, stress and metrical pattern.

Figure 1. The effect of lengthening, stress and metrical pattern on lengthening detection across speech rates (in Spanish).



The figure shows that lengthening increases the detection rate. This is a similarity between both studies. The figure also shows an effect of stress: stress increases the detection rate in the dactylic and iambic patterns. However, the detection rate of strong syllables in the trochaic pattern was not higher than the detection rate of weak syllables in the overall patterns. Weak target syllables in the dactylic pattern display higher detection rates than strong syllables in the trochaic pattern. This is a difference with respect to Z&P (2010). They found a clear difference in detection rates: lengthening on stressed syllables was always better detected than lengthening on unstressed syllables, regardless of the metrical pattern. But as figure 1 shows, in Spanish this outcome was only partially confirmed: the strong syllables in the trochaic pattern did not display better detection rates than the weak syllables. In addition, the effect of stress in Spanish, although present, is smaller than the effect of stress in English.

In conclusion, while Z&P (2010) found a large stress effect in English, in Spanish the effect of stress was rather small.

III.1.2 Interaction of metrical pattern and serial position

We can compare the interaction effect of metrical pattern and serial position, which together determine if a syllable is stressed or not. Figures 2 and 3 show this interaction in the quick and slow speech rate respectively.

Let us start with the quick speech rate. Figure 2 shows that the detection rates in the trochaic and iambic patterns are comparable. Also the stress effect is comparable in these two metrical patterns: strong syllables produce better detection rates than weak syllables in the trochaic and iambic pattern.

Clearly, the dactylic pattern displays the highest detection rates and also a larger stress effect than the trochaic and iambic pattern. At the quick speech rate, not only is the dactylic pattern the one producing the highest detection rate; weak syllables in this pattern even display higher detection rates than strong syllables in the trochaic and iambic meters. This fact shows that the effect of the dactylic metrical pattern is larger than the effect of stress at the quick speech rate.

Fig. 2. The interaction between metrical pattern and serial position for the quick speech rate (in Spanish).

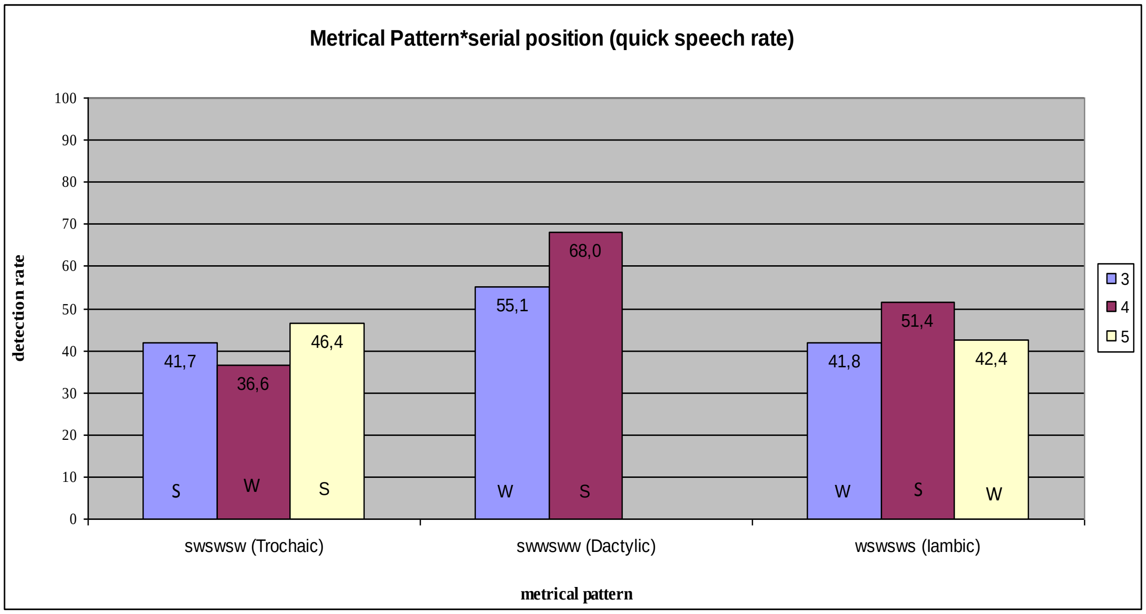
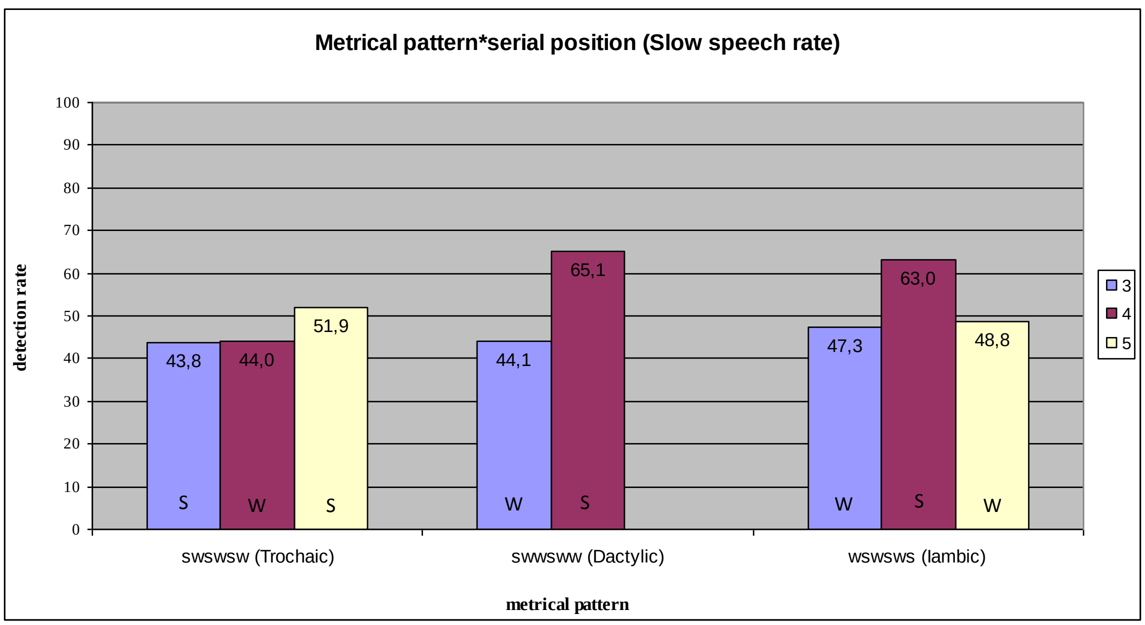


Fig. 3. The interaction between metrical pattern and serial position for the slow speech rate (in Spanish).



At the slow speech rate, Figure 3 shows that detection rates in the trochaic pattern are the lowest. The iambic and dactylic patterns have comparable detection rates. Also their stress effect is comparable, and larger than the stress effect of the trochaic pattern at this speech rate.

Interestingly, the trochaic and iambic patterns at the slow speech rate have higher detection rates than at the quick speech rate. This could point to an effect of the slow speech rate on detection rate; nevertheless, the dactylic pattern at the slow speech rate has lower detection rates than at the quick speech rate. Apparently, the slow speech rate has a negative influence on the perception of target syllables in the dactylic pattern.

In the discussion we come back to the analysis of the hit rates, compared to the outcomes in English.

III.2 Reaction times

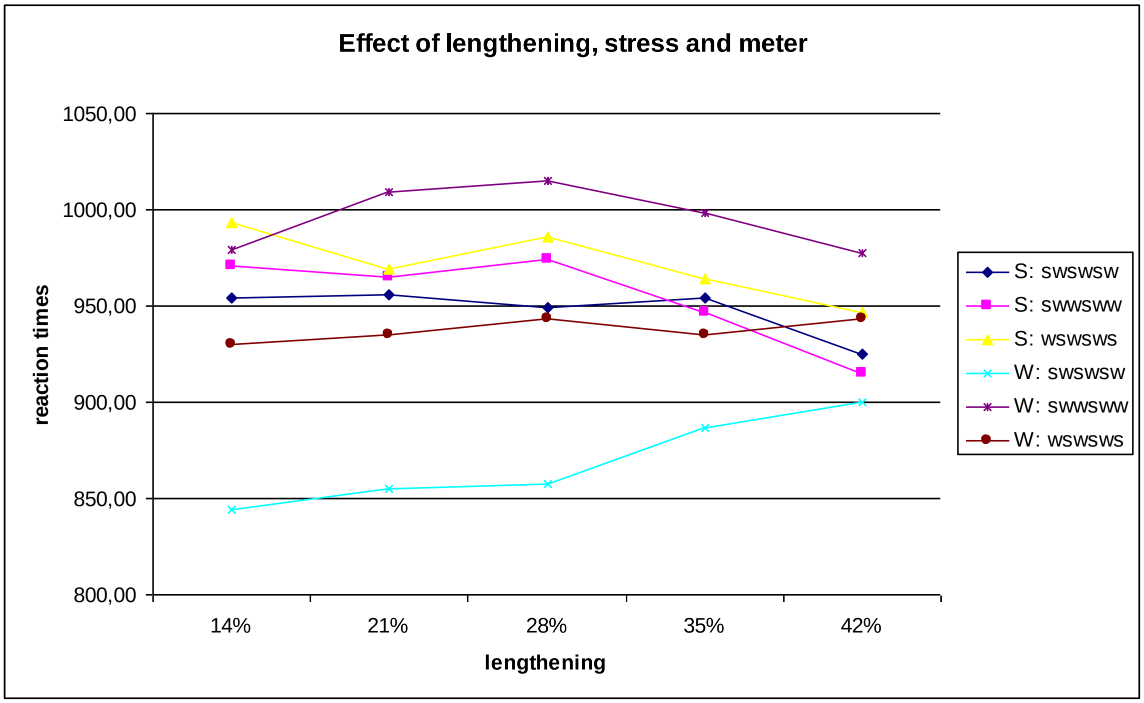
In the present study, not only the detection rates, but also the reaction times were recorded, unlike the English study by Z&P. In this section the main results regarding reaction times in Spanish will be presented.

III.2.1 Effect of lengthening, stress and meter

The effect of lengthening, stress and metrical pattern on reaction times is shown in Figure 4. This figure shows two trends. The first trend, observed for 4 of the 6 syllable groups, shows that reaction times decrease as lengthening factors increase. Weak syllables in the dactylic pattern have greater reaction times when syllables are lengthened with 14% and 28%, but from factor 35% on reaction times decrease. Strong syllables in all metrical patterns register faster reaction times, especially with lengthening factor 42%.

The second trend is exemplified by 2 of the 6 syllable groups: here, reaction times do not decrease but rather increase as the lengthening factors increase. Weak syllables in the trochaic and iambic patterns display this behaviour. Especially weak syllables in the trochaic pattern display higher reaction times for lengthening factor 35% and higher; this increase is smaller in weak syllables in the iambic pattern.

Figure 4. The effect of lengthening, stress and metrical pattern on reaction times across speech rates (in Spanish).



In conclusion, the effect of lengthening, stress and meter on reaction times is irregular.

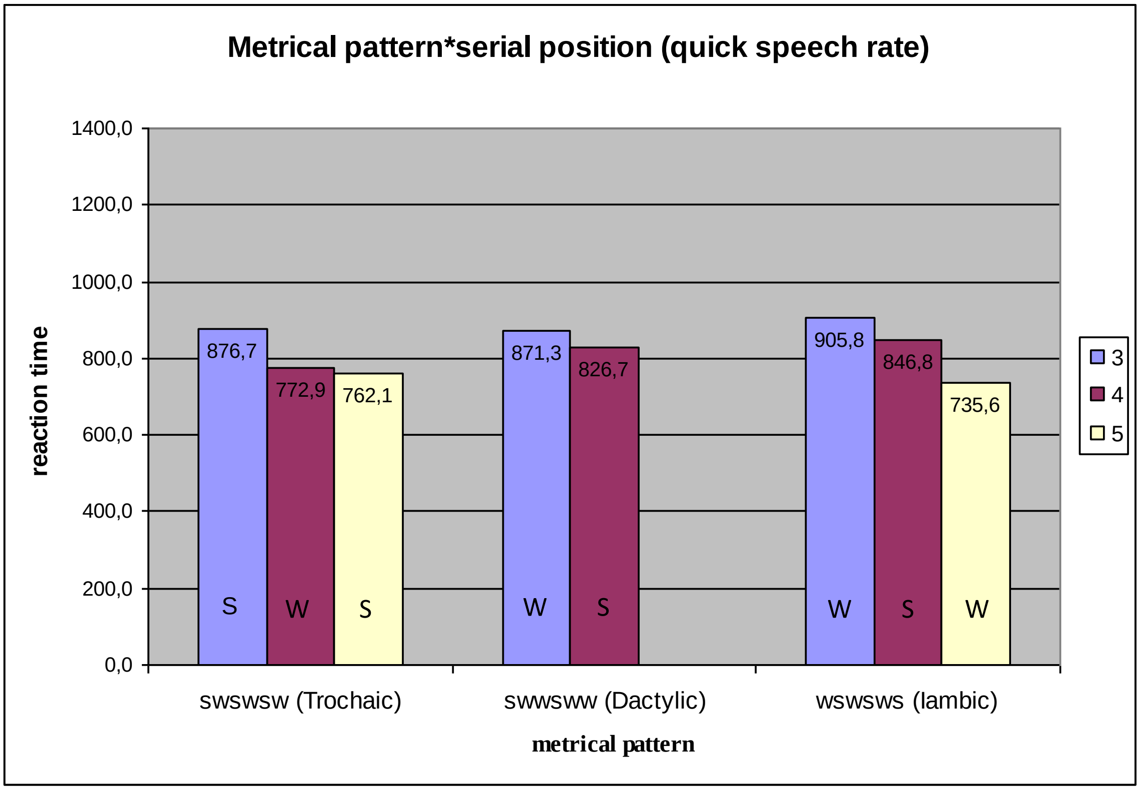
III.2.2 Interaction of metrical pattern and serial position

For the analysis of the reaction times, only the correct responses will count. Figures 5 and 6 show the reaction times for the quick and slow speech rate respectively.

Quick speech rate. Figure 5 shows that at the quick speech rate, the three metrical patterns are comparable. The iambic pattern has slight longer reaction times on the third and fourth serial positions. Syllables on the fifth serial position of the iambic pattern have the fastest reaction times.

The third serial position has the longest reaction times in the three metrical patterns. Each metrical pattern shows the same behaviour: reaction times for targets in the third serial position are the longest and in the fifth serial position are the shortest[4]. This could point to faster responses at the end of the sentence.

Fig. 5. The interaction between metrical pattern and serial position for the quick speech rate (in Spanish).



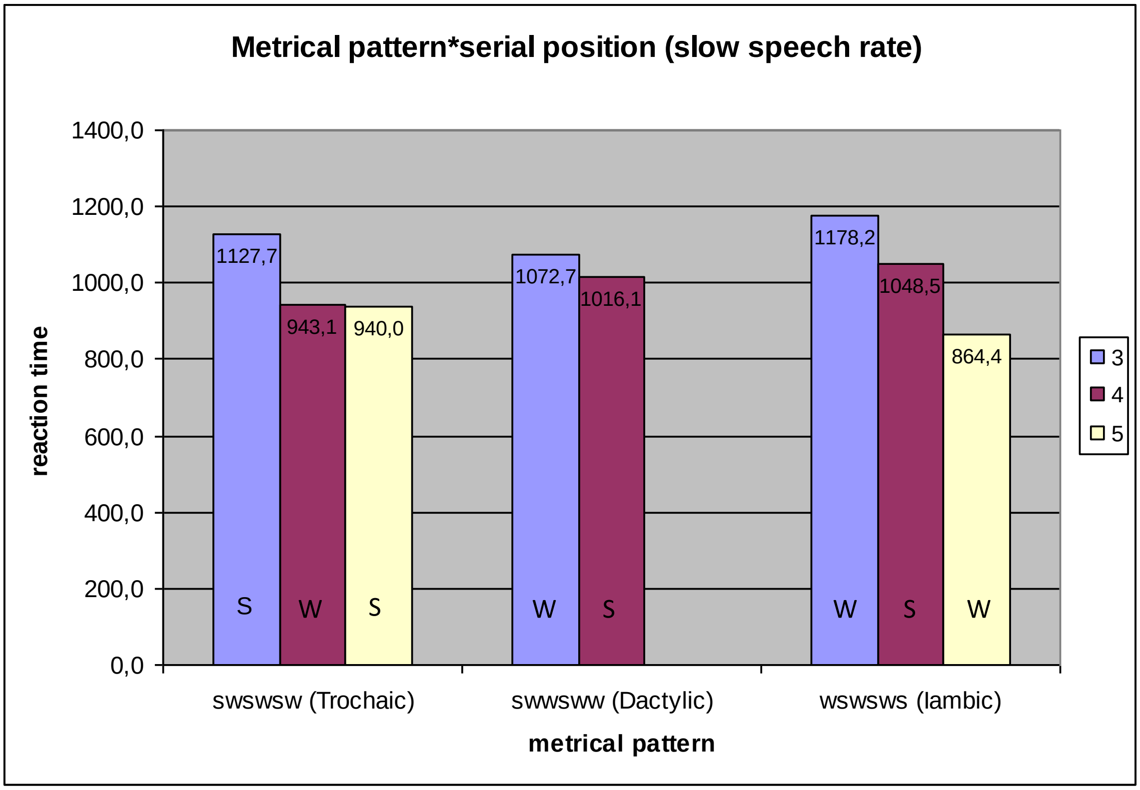
Stress has no effect on reaction times. Strong syllables have longer reaction times when they are located on the third serial position, but shorter reaction times when they are on the fourth serial position, and even shorter on the fifth serial position. The same pattern applies for weak syllables. Only serial position has an effect on reaction times.

Slow speech rate. Figure 6 shows that at the slow speech rate, exactly the same characteristics as in the quick speech rate are present. Reaction times are comparable in the three metrical patterns, the iambic pattern has longer reaction times on the third and fourth serial positions and the fastest on the fifth serial position; per metrical pattern, the third serial position has always the longest reaction times and the fifth serial position the

[4] In the dactylic pattern there are no targets on the fifth serial position, but targets on the fourth serial position have shorter reaction times than targets on the third serial position.

shortest reaction times and stress has no effect on reaction times; only serial position determines how fast a response is given.

Fig. 6. The interaction between metrical pattern and serial position for the slow speech rate (in Spanish).



To conclude, the difference between both speech rates is that reaction times at the slow speech rate are always longer than the equivalent targets at the quick speech rate. The fifth serial position of the iambic pattern has the fastest reaction times.

IV GENERAL DISCUSSION

The present thesis aimed to replicate the study by Z&P (2010) using Spanish as target language. The main research questions regarded the effect of stress and metrical pattern on duration perception. Results indicated that the effect of stress on duration perception was small. Lengthening perception was only in a limited extent advantaged by strong syllables. Importantly, metrical pattern had an effect on lengthening perception, showing that the dactylic pattern had the highest hit rates. Other outcomes of the research were that serial position indeed had an effect on duration perception: targets on the fourth syllable were better detected than targets at the third and fifth serial positions. Finally, the slow speech rate favored detection rates.

The hypotheses were mostly confirmed. Especially important was the effect of metrical pattern in Spanish. As hypothesized, the trochaic pattern did not produce better detection rates. A possible reason for this outcome is that the trochaic pattern is not prevalent in Spanish. Interestingly, this outcome is contrary to Quené & Port (2005) who found no effect of metrical expectancy.

On top of that, the hypothesis regarding the effect of speech rate was also confirmed. Lengthening occurring on target syllables at the slow speech rate was better identified than the same amount of lengthening at the quick speech rate. The hypothesis that lengthening on a target syllable occupying the 5^{th} position would be better detected than lengthening occurring in the 3^{rd} and 4^{th} positions was not confirmed, since the 4^{th} position turned out to facilitate duration perception.

Since this study intended to replicate Z&P (2010), we should compare results. The main outcomes found by Z&P (2010) were that stress and lengthening increased detection rate, that the trochaic pattern produced better detection rates, the slow speech rate increased the detection rate, and in non-trochaic patterns, weak syllables occurring near the end of the sentence showed better detection rates than weak syllables occurring in the middle of the sentence.

A comparison between detection rates in Spanish and in English shows that in English, the trochaic pattern displayed a higher detection rate than both the iambic and the dactylic meter (Z&P 2010: 854). In Spanish, the trochaic pattern did not display high detection rates; on the contrary, detection rates in this pattern were the lowest. Clearly, the trochaic pattern does not favour lengthening identification in Spanish, while it does in English.

Strong syllables had comparable detection rates at both speech rates in English and Spanish. However, the relevant difference regards the detection rates on weak syllables. In Spanish, weak syllables have higher detection rates than in English. For instance, in the dactylic pattern of Spanish, weak syllables in the third serial position have 55% hit rates at the quick speech rate and 44% at the slow speech rate. In English, hit rates for weak syllables in the same meter and serial position are approximately 17% and 15% respectively. The iambic and trochaic patterns display the same behaviour[5]. This is the most remarkable finding in the comparison. Lengthening on weak syllables, due to absence of vowel reduction in Spanish, is still good identified, while in English, where vowel reduction is present, identification is more difficult. Finally, the effect of speech rate in English is less regular than in Spanish. In Spanish, with the exception of the dactylic pattern, lengthening at the slow speech rate was better identified than at the quick speech rate. In English the overall effect of speech rate is marginal.

Summarizing, the detection rates in the present study differ from the findings of Z&P (2010) for English. The reason for the different outcomes is obviously the languages used as targets, since English and Spanish have different patterns. As commented above, for Spanish, the majority of the hypotheses were confirmed.

The present study considered reaction times while Z&P did not. Therefore, there is no comparison possible. For Spanish, results clearly showed that reaction times at the slow speech rate were longer than at the quick speech rate. Interestingly, serial position is the only factor with an effect on reaction times, with the later positions favouring faster reaction times. This could point to a recency effect (Murdock 1962) of the fifth serial position. Targets on the third serial position show that the larger the reaction time, the lower the detection rate. Probably these syllables, due to their position in the sentence, are more difficult to recall and demand more time to accomplish the task. Serial positions 4 and 5 do not display this regular pattern.

[5] There is only one peculiarity in English: weak syllables in the fourth serial position of the trochaic pattern at the slow speech rate have 48% hit rates, and only 23% at the quick speech rate. In Spanish there is no such difference in hit rates for the same pattern and serial position.

As for detection rates, the attentional bounce hypothesis predicted that detection of lengthening on strong syllables would be favoured in comparison to weak syllables. This was confirmed. Nevertheless, results showed that detection rates on weak syllables were not as low as they were in English. As for reaction times, according to Shields et al. (1974) and Pitt & Samuel (1990), these should be faster for accented syllables than for unaccented syllables. However, results indicated that stress had no effect on reaction times. Only serial position did determine if a reaction time was fast (at the end of the sentence) or slower (at the middle of the sentence). The attentional bounce hypothesis was thus not confirmed. Based on the outcomes of both studies, we can conclude that the attentional bounce hypothesis applies to English, but its influence in Spanish is rather limited.

Finally, we must point out a possible confound. Recall that absolute duration of syllables was controlled by matching the duration of the syllables in the strong-quick condition with the syllables in the weak-slow condition; however an analysis of the duration of syllables per metrical pattern demonstrated that syllables in the dactylic pattern had a longer duration than the other two patterns. The longer duration of (baseline) syllables in the dactylic pattern represents a possible confound; this could be the reason why participants found it easier to identify lengthening in the dactylic pattern.

In conclusion, contrary to English, in Spanish stress has a small effect on duration perception. The dactylic metrical pattern produces higher detection rates than the iambic and trochaic patterns. Reaction times in Spanish show that stress does not benefit faster reaction times, and reaction times to targets located in the last syllables of the sentence are faster than those located in the middle of the sentence.

APPENDIX I: Stimuli

Target syllables are underlined; strong syllables are in capital letters and weak syllables in small letters. Duration of target syllables are expressed in milliseconds.

1.1 DACTYLIC STIMULI UTTERANCES

Target syllable occupies the 3rd position:

[a]

EL le da CAtedra	da: quick 126	slow 140
GRAba la Musica	la: quick 80	slow 111
COMprala Rapido	la: quick 114	slow 117

[i]

Toma mi BRUjula	mi: quick 145	slow 167
EL es mi Heroe	mi: quick 187	slow 169
Dame mi Codigo	mi: quick 139	slow 203

[u]

Seca tus Lagrimas	tus: quick 181	slow 184
Eres su Idolo	su: quick 247	slow 256
Dame tu Numero	tu: quick 127	slow 134

Target syllable occupies the 4th position:

[a]

PONgale MAS alcohol	MAS: quick 242	slow 398
VENdeme PAN y sal	PA: quick 131	slow 234
LLAmame MAS tarde	MAS: quick 253	slow 331

[i]

VEN pero SIN ella	SIN: quick 281	slow 337
CANdida SI quiere	SI: quick 233	slow 322
LAzaro SI vive	SI: quick 269	slow 363

[u]

Esta es SU casa	SU: quick 242	slow 292
Armalo TU solo	TU: quick 154	slow 204
Estos son TUS dones	TUS: quick 220	slow 302

1.2 IAMBIC STIMULI UTTERANCES

Target syllable occupies the 3rd position:

[a]

la CREma LIMpia BIEN	ma: quick 133	slow 158
la Niña NO esTA	ña: quick 106	slow 162
la REIna ES genTIL	na: quick 118	slow 136

[i]

ya Casi LLEga FER	si: quick 135	slow 179
venDRE si VIEnes TU	si: quick 125	slow 193
tenDRE mi POSter HOY	mi: quick 166	slow 180

[u]

llaMO tu BUEN anDRES	tu: quick 113	slow 144
se FUE tu Tio CHRIS	tu: quick 118	slow 137
le DIO un BUEN guiON	un: quick 85	slow 155

Target syllable occupies the 4th position:

[a]

no QUIEro MAS pasTEL	MAS: quick 192	slow 352
tamBIEN venDRA miGUEL	DRA: quick 152	slow 162
joSE esTA feLIZ	TA: quick 81	slow 134

[i]

aUN aSI gaNO	SI: quick 148	slow 348
aPEnas VI a TRES	VI: quick 122	slow 223
aYER venCI a SEIS	CI: quick 191	slow 224

[u]

la VI con UN gaLAN	NUN: quick 160	slow 193
el PEZ aZUL muRIO	ZUL: quick 177	slow 268
pesCO aTUN del SUR	TUN: quick 158	slow 282

Target syllable occupies the 5th position:

[a]

la GOma Pega BIEN	ga: quick 126	slow 148
al FIN lleGO la PAZ	la: quick 129	slow 161
maNJAna VOY al MAR	al: quick 87	slow 141

[i]

jaVIER comPRO mi BUEY	mi: quick 151	slow 165
mamá venDO mi PIE	mi: quick 167	slow 170
aUN no SE si VA	si: quick 157	slow 222

[u]

maNUEL será un REY	un: quick 114	slow 169
daNIEL cuiDO tu PEZ	tu: quick 114	slow 147
al FIN coMIO su PAN	su: quick 129	slow 187

1.3 TROCHAIC STIMULI UTTERANCES

Target syllable occupies the 3rd position:

[a]

MAX veRA mi Casa	RA: quick 100	slow 121
EL esTA coRRIENdo	TA: quick 99	slow 140
TU tenDRAS fuTUro	DRAS: quick 127	slow 171

[i]

HOY saLI con PAUla	LI: quick 136	slow 173
YO beBI tres COpas	BI: quick 131	slow 234
HOY coRRI dos MIllas	RRI: quick 124	slow 140

[u]

EL aUN no SAbe	U: quick 79	slow 104
ESte TUL es LINdo	TU: quick 147	slow 186
JUAN y TU romPIEron	TU: quick 172	slow 233

Target syllable occupies the 4th position:

[a]

PRUEba ESta SOpa	ta: quick 66	slow 116
EL coCIna MUY bien	na: quick 93	slow 140
PEdro BAIla TANgo	la: quick 124	slow 141

[i]

QUIEren PAN y Agua	ni: quick 144	slow 151
EL venDIO mi COche	mi: quick 132	slow 144
DAle MAS si QUIEre	si: quick 153	slow 199

[u]

TU tenDRAS un PErro	un: quick 100	slow 144
HOY venDRA tu TIa	tu: quick 120	slow 134
YA lleGO su HOra	su: quick 149	slow 218

Target syllable occupies the 5th position:

[a]

EL neGO esTAR mal	TAR: quick 200	slow 286
ALdo QUIEre MAS sal	MA, quick: 173	slow 390
SANta COMba VA mal	VA: quick 135	slow 225

[i]

YO aYER dorMI bien	MI: quick 171	slow 182
CLAra LOpez SI fue	SI: quick 173	slow 261
EL maNJAna SI va	SI: quick 142	slow 231

[u]

TOdo CUESta UN sol	UN: quick 106	slow 174
Ellos Aman SU voz	SU: quick 177	slow 293
YA lleGO seGUN sol	GUN: quick 73	slow 312

APPENDIX II: Scrip lengthening syllables

```
# LengthenSyll.praat
#
# Script for PRAAT 5.1 (www.praat.org)
#
# This script takes one Sounds and one associated TextGrids as input.
#
# This Praat script was written for the thesis work of Lisette van
Delft.
#
# (c) 2009 Hugo QuenÃ©, Utrecht University [H.Quene@uu.nl]
# HQ 20090210 initial release, title AdjustDur.praat
# HQ 20090309 added optional transposition of intonation, title
AdjustDurPitch.praat
#     The resulting pitch contour takes the pitch points from the
second Sound,
#     shifted so that their average is equal to the average pitch of
the first Sound.
#     The pitch points are then copied to the first Sound, so that the
pitch points
#     keep their relative timing position within each segment.
# HQ 20090310 removed bug in computation of sent2d
# HQ 20110314 adapted for thesis of Mariella Marquez Mendoza:
#     * work with single Sound and single TextGrid
#     * create multiple versions of Sound, with target syll (annotated
in TextGrid)
#           lengthened to 'lengthenfactor' relative to original
# HQ 20110321 added printline command to report the following features
of
#     original and manipulated syllable:
#           sent:       name of Sound object
#           labelsyl: label of target syllable in TextGrid
#           btsyl:      begin time of target syllable
#           etsyl:      end time of target syll
#           oridur:     duration of target syllable in original, etsyl-
btsyl
#           percent:    amount of change in duration of target syll, in
percent
#           newdur:     computed new duration of target syll
#           actualdur: actual new duration of target syll, determined
by
#                 comparing durations of resynthesized and original
versions
#     All reported durations and times are rounded to ms precision.

# This script requires that one Sound object and one TextGrid object
is/are
# selected when the script is called.
#if ( numberOfSelected("Sound") != 1 or numberOfSelected("TextGrid") !=
1 )
#     exit Exactly one Sound and one (associated) TextGrid must be
selected.
#endif

# set FULL (!) path to working directory for read and write
```

```
# relative path specificiations do not work well
## Mariella: ADJUST THIS for your configuration
indir$ = "/Users/Hugo/MariellaMarquezMendoza/thesis/testarea"
# blank line in console window
# printline

# sent1 is the original to be manipulated
#sent1id = selected("Sound",1)
#sent1$ = selected$("Sound",1)
#textgrid1id = selected("TextGrid",1)

# ask interactively for minimum pitch and targetduration values
form Analysis and resynthesis parameters
#   comment _
#     comment Current folder for opening and saving files is
#     comment "'indir$'"
   positive minimum_pitch_(Hz) 70
   positive maximum_pitch_(Hz) 300
      comment Lengthening factor is new syllable duration, relative to
original
   real lengthenfactor 1.14
   comment Clear the Info window?
#   comment (This will permanently remove all contents from the Info
window).
   boolean clear_Info_window 0
endform

# text string version of lengthening factor expressed as percentage
aux = round('lengthenfactor'*100)
percent$ = "'aux'"
# granularity of duration points, shortest distance between points
shortperiod = 1/'maximum_pitch'

if clear_Info_window = 1
      # erase entire console window
      clearinfo
endif

# print header line with column names to Info window
#printline 'sent1$' "'labsyl$'" 'btsyl:3' 'etsyl:3' 'dursyl:3'
'percent$' 'newdur:3' 'actdur:3'
printline # sent labelsyl btsyl etsyl oridur percent newdur actualdur

Create Strings as file list... fileList 'indir$'/*.TextGrid
nfiles = Get number of strings
list = selected("Strings")
for ifile from 1 to 'nfiles'

      select 'list'
      fn$ = Get string... 'ifile'
      # read textgrid
      Read from file... 'indir$'/'fn$'
      textgrid1id = selected("TextGrid",1)
      textgrid1$ = selected$("TextGrid",1)
      # read corresponding sound, same filename, extension .wav
      Read from file... 'indir$'/'textgrid1$'.wav
      sent1id = selected("Sound",1)
```

```
      sent1$ = selected$("Sound",1)
      # do things with these files

      # printline Processing Sound 'sent1$', lengthening syllable to
'percent$' ...

      # this script assumes that the first interval and the last
interval
      # have no label. The corresponding parts of
      # sound1 will not be changed in duration.

      # The intermediate intervals (normally a single syllable) will be
lengthened,
      # with subsequent resynthesis and storage.
select 'textgrid1id'
      sent1t = Get total duration
      sent1ns = Get number of intervals... 1
      sent1b = Get end point... 1 1
      sent1e = Get start point... 1 'sent1ns'
      sent1d = 'sent1e' - 'sent1b'

      # create Manipulation object
      select 'sent1id'
      manip1id = To Manipulation... 0.010 'minimum_pitch'
'maximum_pitch'
      manip1$ = selected$("Manipulation")
      Edit
      editor Manipulation 'sent1$'
            Set duration range... 0.40 2.20
            # Stylize pitch (2 st)
      endeditor

      for i from 1 to 'sent1ns'
            # check whether labels are identical ?
            select 'textgrid1id'
            seg1b = Get start point... 1 'i'
            seg1e = Get end point... 1 'i'
            seg1d = seg1e-seg1b
            lab1$ = Get label of interval... 1 'i'
            if i=1
                  factor=1
            elsif i='sent1ns'
                  factor=1
            else
                  factor = 'lengthenfactor'
                  labsyl$ = lab1$
                  dursyl = seg1d
                  btsyl = seg1b
                  etsyl = seg1e
            endif

            call adddurpoints 'manip1id' 'manip1$' 'seg1b' 'seg1e'
'factor'
            # drastic PSOLA manipulation may yield strange artefacts,
see book Dutoit
            if factor > 2.0
                  printline ! Warning: Sound 'sent1$', segment 'i'
```

```
('lab1$'), factor 'factor:5' may be too large
            elsif factor < 0.5
                  printline ! Warning: Sound 'sent1$', segment 'i'
('lab1$'), factor 'factor:5' may be too small
            endif
      endfor

procedure adddurpoints mid mani$ s1b s1e fact
# add two duration points, in manipulation object passed as parameters,
# at positions (just after) s1b and (just before) s1e, of value fact
      select 'mid'
      s1b = s1b+(shortperiod/2)
      s1e = s1e-(shortperiod/2)
# no need to open new ManipulationEditor window, use existing one
#     Edit
      editor Manipulation 'mani$'
            Add duration point at... 's1b' 'fact'
            Add duration point at... 's1e' 'fact'
      endeditor
endproc

      # after all duration points are added, we can close the
Manipulation editor
      editor Manipulation 'mani$'
            Close
      endeditor
      # and rename the Manipulation object
      select 'manip1id'
      Rename... 'sent1$'_'percent$'
      # and save the modified Manipulation object for later reference
      Save as binary file without Sound...
'indir$'/'sent1$'_'percent$'.Manipulation
      # and resynthesize the original Sound with adjusted durations!
      Get resynthesis (overlap-add)
      resyn1id = selected("Sound")

      # report info for each Sound
      # printline Sound 'sent1$', target syllable "'labsyl$'"
lengthened to 'percent$'%
      newdur = 'dursyl'*'lengthenfactor'
      resyn1dur = Get total duration
      # compute actual syllable duration from difference re original
      actdur = resyn1dur-sent1t+dursyl
      printline 'sent1$' "'labsyl$'" 'btsyl:3' 'etsyl:3' 'dursyl:3'
'percent$' 'newdur:3' 'actdur:3'

      # Als je wilt dat het gemanipuleerde geluidsbestand automatisch
worden
      # weggeschreven, dan moet je het hekje en de daaropvolgende
spatie
      # verwijderen uit de twee hiernavolgende regels:
      Write to WAV file... 'indir$'/'sent1$'_'percent$'.wav
      # printline    saved as 'indir$'/'sent1$'_'percent$'.wav

      # cleanup
      # Als je wilt dat het gemanipuleerde geluidsbestand wordt bewaard
in Praat,
```

```
	# dan moet je een hekje toevoegen aan het begin van
hiernavolgende regels:
	select 'manip1id'
	plus 'resyn1id'
	Remove

	# restore initial selection when this script was called?
	# Als je wilt dat het originele geluidsbestand en textgrid wordt
bewaard in Praat,
	# dan moet je een hekje toevoegen aan het begin van
hiernavolgende regels:
	select 'sent1id'
	plus 'textgrid1id'
	Remove

# for i from 1 to nfiles
endfor

# global cleanup
select 'list'
Remove

printline # Total 'nfiles' files processed
# finish
```

APPENDIX III: Practice items

Block 1:

1. target 4, trochaic: EL lo TIEne TOdo (lengthened 35%)
2. target 5, dactylic: DIjo que EL no va (not lengthened)
3. target 5, trochaic: CLAro SI venDRE hoy (lengthened 42%)
4. target 3, iambic: no SE si QUIEre MAS (lengthened 14%)
5. target 4, o, iambic: aBEL ceNO aRROZ (not lengthened)

Block 2:

6. target 3, trochaic: EL poDRA haCERlo (not lengthened)
7. target 4, trochaic: CARla CANta LINdo (not lengthened)
8. target 3, iambic: paBEL lo VIO aYER (lengthened 42%)
9. target 4, iambic: coMIO aTUN y PAN (lengthened 21%)
10. target 5, iambic: quiZAS marTIN la VIO (lengthened 28%)

Block 3:

11. target 3, trochaic: SE que TU lo CREes (lengthened 14%)
12. target 5, iambic: pasCUAL cumPLIO su MES (lengthened 28%)
13. target 3, dactylic: BOta la CAScara (not lengthened)
14. target 5, iambic: le QUIEro MUcho MAS (not lengthened)
15. target 3, trochaic: El ceRRO la TIENda (lengthened 35%)

Block 4:

16. target 3, dactylic: VENdame PLAtanos (not lengthened)
17. target 4, dactylic: ALvaro SI puede (lengthened 21%)
18. target 4, trochaic: VEN a CAsa PRONto (lengthened 35%)
19. target 4, dactylic: Eso lo SE también (lengthened 42%)
20. target 4, iambic: le CUESta UN reAL (not lengthened)

APPENDIX IV: Participants

Laptop 1

```
participant 1:
  id                         : p01JuanManuelLucas
  created                    : 2011-04-11 10:52:15 +02
  modified                   : 2011-04-11 10:52:15 +02
  birthdate                  : "1983-03-03"
  sex                        : "male"

participant 2:
  id                         : p02JorgePardo
  created                    : 2011-04-11 16:09:41 +02
  modified                   : 2011-04-11 16:09:42 +02
  birthdate                  : "1990-05-06"
  sex                        : "male"

participant 3:
  id                         : p03JulioLopezOliva
  created                    : 2011-04-12 10:34:24 +02
  modified                   : 2011-04-12 10:34:24 +02
  birthdate                  : "1987-10-16"
  sex                        : "male"

participant 4:
  id                         : p04FranBarea
  created                    : 2011-04-12 12:07:43 +02
  modified                   : 2011-04-12 12:07:43 +02
  birthdate                  : "1989-12-24"
  sex                        : "male"

participant 5:
  id                         : p05JuanJoseCarracedoJusto
  created                    : 2011-04-12 14:33:06 +02
  modified                   : 2011-04-12 14:33:06 +02
  birthdate                  : "1989-06-25"
  sex                        : "male"

participant 6:
  id                         : p06CeciliaLaBorda
  created                    : 2011-04-12 15:56:20 +02
  modified                   : 2011-04-12 15:56:20 +02
  birthdate                  : "1986-04-22"
  sex                        : "female"

participant 7:
  id                         : p07GuillermoVerdu
  created                    : 2011-04-13 10:12:24 +02
  modified                   : 2011-04-13 10:12:24 +02
  birthdate                  : "1990-01-23"
  sex                        : "male"

participant 8:
  id                         : p08SergioPenavades
  created                    : 2011-04-13 12:30:22 +02
```

```
  modified                : 2011-04-13 12:30:22 +02
  birthdate               : "1990-01-09"
  sex                     : "male"

participant 9:
  id                      : p09MyriamCifuentes
  created                 : 2011-04-13 16:31:40 +02
  modified                : 2011-04-13 16:31:40 +02
  birthdate               : "1986-02-12"
  sex                     : "female"

participant 10:
  id                      : p10MarioRodriguez
  created                 : 2011-04-14 12:10:20 +02
  modified                : 2011-04-14 12:10:20 +02
  birthdate               : "1987-03-30"
  sex                     : "male"

participant 11:
  id                      : p11AngelGonzales
  created                 : 2011-04-14 14:56:52 +02
  modified                : 2011-04-14 14:56:52 +02
  birthdate               : "1989-01-21"
  sex                     : "male"

participant 12:
  id                      : p12ElenaArraez
  created                 : 2011-04-14 17:03:07 +02
  modified                : 2011-04-14 17:03:07 +02
  birthdate               : "1986-02-04"
  sex                     : "female"
```

Laptop 2

```
participant 1:
  id                      : p01CarlosRuiz
  created                 : 2011-04-09 08:38:59 +02
  modified                : 2011-04-09 08:38:59 +02
  birthdate               : "1980-12-31"
  sex                     : "male"

participant 2:
  id                      : p02DavidMartin
  created                 : 2011-04-11 12:08:11 +02
  modified                : 2011-04-11 12:08:11 +02
  birthdate               : "1989-10-31"
  sex                     : "male"

participant 3:
  id                      : p03AlejandroMartin
  created                 : 2011-04-11 14:32:48 +02
  modified                : 2011-04-11 14:32:48 +02
  birthdate               : "1987-07-04"
  sex                     : "male"

participant 4:
```

```
  id                        : p04TirsoMoreno
  created                   : 2011-04-11 15:50:42 +02
  modified                  : 2011-04-11 15:50:42 +02
  birthdate                 : "1985-04-18"
  sex                       : "male"

participant 5:
  id                        : p05PatriciaRodriguez
  created                   : 2011-04-12 10:24:03 +02
  modified                  : 2011-04-12 10:24:03 +02
  birthdate                 : "1990-06-21"
  sex                       : "female"

participant 6:
  id                        : p06CristinaDeLasHerasEsteban
  created                   : 2011-04-12 11:35:04 +02
  modified                  : 2011-04-12 11:35:04 +02
  birthdate                 : "1986-02-01"
  sex                       : "female"

participant 7:
  id                        : p07GonzaloMunoz
  created                   : 2011-04-12 13:34:38 +02
  modified                  : 2011-04-12 13:34:38 +02
  birthdate                 : "1989-08-22"
  sex                       : "male"

participant 8:
  id                        : p08MiguelRodriguez
  created                   : 2011-04-12 15:09:33 +02
  modified                  : 2011-04-12 15:09:33 +02
  birthdate                 : "1990-01-11"
  sex                       : "male"

participant 9:
  id                        : p09JoaquinFernandez
  created                   : 2011-04-12 17:10:58 +02
  modified                  : 2011-04-12 17:10:58 +02
  birthdate                 : "1989-11-02"
  sex                       : "male"

participant 10:
  id                        : p10DiegoPascual
  created                   : 2011-04-13 10:08:03 +02
  modified                  : 2011-04-13 10:08:03 +02
  birthdate                 : "1990-03-16"
  sex                       : "male"

participant 11:
  id                        : p11DavidSignoret
  created                   : 2011-04-13 11:31:32 +02
  modified                  : 2011-04-13 11:31:32 +02
  birthdate                 : "1990-04-04"
  sex                       : "male"

participant 12:
  id                        : p12RamonInarejos
```

```
  created                    : 2011-04-13 12:59:16 +02
  modified                   : 2011-04-13 12:59:16 +02
  birthdate                  : "1990-06-23"
  sex                        : "male"

participant 13:
  id                         : p13JoseLuisCarreno
  created                    : 2011-04-13 15:53:29 +02
  modified                   : 2011-04-13 15:53:29 +02
  birthdate                  : "1950-06-21"
  sex                        : "male"

participant 14:
  id                         : p14AnaIsabelMaquedaNieto
  created                    : 2011-04-13 17:56:29 +02
  modified                   : 2011-04-13 17:56:29 +02
  birthdate                  : "1989-02-16"
  sex                        : "female"

participant 15:
  id                         : p15MartaCruz
  created                    : 2011-04-14 10:04:08 +02
  modified                   : 2011-04-14 10:04:08 +02
  birthdate                  : "1989-01-12"
  sex                        : "female"

participant 16:
  id                         : p16IsabelGomez
  created                    : 2011-04-14 12:03:40 +02
  modified                   : 2011-04-14 12:03:40 +02
  birthdate                  : "1988-11-30"
  sex                        : "female"

participant 17:
  id                         : p17CarlosNavarro
  created                    : 2011-04-14 16:01:11 +02
  modified                   : 2011-04-14 16:01:11 +02
  birthdate                  : "1986-06-18"
  sex                        : "male"

participant 18:
  id                         : p18ElenaAlmarcha
  created                    : 2011-04-14 18:02:04 +02
  modified                   : 2011-04-14 18:02:04 +02
  birthdate                  : "1989-09-03"
  sex                        : "female"
```

REFERENCES

Hawkins, S. 2003. Roles and representations of systematic fine phonetic detail in speech understanding. *Journal of Phonetics* 31, 373-405.

Jones, M.R. 1976. Time, our lost dimension: toward a new theory of perception, attention, and memory. *Psychological Review* 83, 323-355.

Jones, M.R. 1990. Learning and the development of expectancies: an interactionist approach. *Psychomusicology* 9, 193-228.

Lehiste, I. 1980. Phonetic manifestation of syntactic structure in English. *Annual Bulletin, Research Institute of Logopedics and Phoniatrics, University of Tokyo* 14, 1-27.

Martin, J.G. 1972. Rhythmic (hierarchical) versus serial structure in speech and other behaviour. *Psychological Review* 79, 487-509.

Murdock, B. 1962. The serial position effect on free recall. *Journal of Experimental Psychology* 64 (5), 482-488.

Pitt, M.A. & Samuel, A.G. 1990. The use of rhythm in attending to speech. *Journal of Experimental Psychology: Human Perception and Performance* 16, 564-573.

Quené, H. & Port, R.F. 2005. Effects of timing regularity and metrical expectancy on spoken-word perception. *Phonetica* 62 (1), 1-13.

Quené, H. & Port, R.F. 2008. Examples of mixed effects modelling with crossed random effects and binomial data. *Journal of Memory and Language* 59, 413-425.

Sebastián-Gallés, N. & Costa, A. 1997. Metrical information in speech segmentation in Spanish. *Language and Cognitive Processes* 12, 883-887.

Shattuck-Hufnagel, S. & Turk, A. 1996. A prosody tutorial for investigators of auditory sentence processing. *Journal of Psycholinguistic Research* 25, 193-247.

Shields, J.L., McHugh, A. & Martin, J.G. 1974. Reaction time to phoneme targets as a function of rhythmic cues in continuous speech. *Journal of Experimental Psychology* 102, 250-255.

Zheng, X. & Pierrehumbert, J.B. 2010. The effects of prosodic prominence and serial position on duration perception. *Journal of the Acoustical Society of America* 128 (2), 851-859.