

Articulation rate and syllable reduction in Spanish and Portuguese

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Abstract

This study compares canonical and phonetic articulation rates of European Spanish and Portuguese based on radio podcasts. The main goal of the investigation is to establish the degree of syllable deletion based on vowel/consonant elision in both languages. The results show that Portuguese and Spanish speakers exhibit no difference in canonical articulation rate but Portuguese speakers reduce syllables significantly more than Spanish speakers due to vowel elision in post-stressed and final position, which results in longer, but fewer syllables per second.

1. Introduction

Haugen (1966) coined the term ‘semi-communication’ for situations where speakers of closely related languages communicate using only their respective native language. This is also referred to as ‘receptive multilingualism’ (Braunmüller & Zeevaert 2001) or ‘mutual intelligibility’. Focusing on Scandinavian languages, Haugen (1966) was one of the first to study the mutual intelligibility of closely related Scandinavian languages. Generally, Danish, Swedish and Norwegian are so closely related that the speakers of these languages can communicate each using their own language (Delsing & Lundin Åkesson 2005, Bø 1978, Maurud 1976).

Little research has been conducted on the mutual intelligibility of closely related languages within the Romance language area. Jensen (1989) investigated how well South-American based speakers of Spanish and Portuguese understand each other, targeting the following questions:

1. Are the regional varieties of Spanish and Portuguese spoken in South America mutually intelligible?
2. If they are mutually intelligible - to what extent?
3. Is the comprehension symmetric or asymmetric?

Jensen (1989) used four different texts for an auditory comprehension test. Spanish-speaking participants listened to a set of Portuguese audio files and Portuguese listeners were confronted with a set of Spanish audio file. Each listening comprehension task was approximately three minutes long and after every listening session the participants had to write down answers to questions about the text in their native language. The

questions were designed in such a way, that in order to give correct answers it was not sufficient to understand single words. Rather, an overall understanding of the text was required.

A disadvantage of this experiment was that the texts used differed across the languages, which makes the intelligibility results difficult to compare. Yet, the genre (stories for children, news article, etc.) was kept constant throughout the languages. Jensen's (1989) results showed that for his study Portuguese (spoken in Brazil) and Spanish (different Latin-American based dialects) are mutually intelligible to a certain extent. The Brazilian group scored 58% while the Spanish speaking group scored 50%. The difference between the scores was big enough to be statistically significant.

Jensen (1989) points out that this result is only valid for passive listening. Aided by gestures and visual contact the intelligibility in a face-to-face conversation might be higher. Concerning his third research question whether the comprehension between Spanish and Portuguese is symmetric or asymmetric, Jensen showed that the Portuguese (speakers) understand speakers of Spanish to a significantly higher degree than the other way around.

When correlating intelligibility scores with linguistic distance scores, the degree of intelligibility can be largely predicted by phonetic distances. This was found by Van Bezooijen & Gooskens (2005) when investigating mutual intelligibility of Dutch, Frisian and Afrikaans.

1.1 Linguistic similarities and differences between Spanish and Portuguese

European Spanish and Portuguese share a common Latin-based background as they both belong to the West Iberian-Romance language branch and based on Jensen's (1989) findings, we assume that European Spanish and European Portuguese are mutually intelligible to a certain degree. Both languages are closely related in terms of structural features, e.g. simple syllable structure CVC and a common lexis (Blasco Ferrer 1996).

However, European Spanish and Portuguese differ significantly in terms of pronunciation. Phonetically, Portuguese shows more similarity to French or Catalan (Mateus & d'Andrade 2000) while Spanish pronunciation is more closely related to Italian pronunciation (Eddington 2004). Moreover, Spanish and Portuguese also show differences in timedness. Most languages can be categorized as either *stress-timed* or *syllable-timed* (Pike 1945). For a syllable-timed language the pronunciation of each

syllable takes approximately the same amount of time. Stress-timed languages, on the other hand, can be defined by having approximately the same amount of time between stressed syllables. Spanish is generally classified as a syllable-timed language. Pike (1945) characterizes Spanish speakers to have a very precisely cut pronunciation articulating syllable by syllable. European Portuguese, on the other hand, shows features of both syllable- and stressed-timedness (Frota & Vigario 2001). To facilitate the classification of isochrony in languages and in contrast to distinguishing languages as one or the other, Dauer (1983) proposes a system of classification. She discards the concept of 'syllable-stressed' and suggests a continuum where languages are classified as more or less close to a base that she calls 'stress based' (Figure 1).

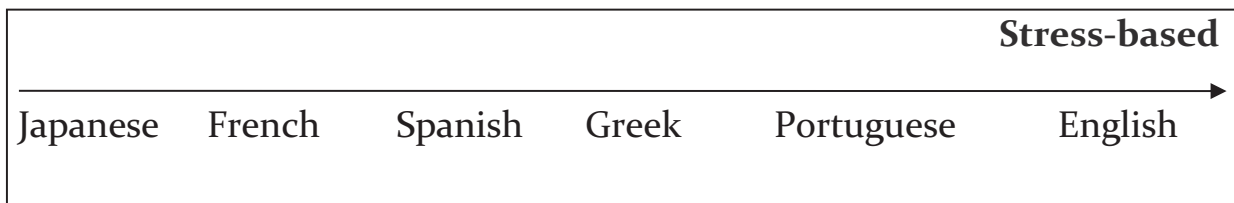


Figure 1: Stress continuum suggested by Dauer (1983: 10)

According to Roach (1998), syllable-timed speech sounds faster to speakers of stress-timed languages. That is, speakers of English perceive Spanish or Italian as faster than Dutch (or other stress timed languages). Another important measure for similarity in pronunciation is the phoneme inventory. Spanish (Castilian) has a smaller inventory of phonemes than Portuguese (Eddington 2004, Mateus & d'Andrade 2000). The Portuguese vowel system contains fourteen phonemic vowels (Figure 2a) while the Spanish language only has five phonemic vowels (Figure 2b).

An additional feature that distinguishes Spanish and Portuguese is that Spanish almost lacks vowel reduction but shows features of consonant reduction. In standard speech the final /d/ is often lost, thus, for example, *usted* (Engl. formal 'you') is normally pronounced [us'tɛ̃].

Compared to Spanish, which shows a small vowel inventory and little vowel variation, Portuguese has a very rich vowel system consisting of nasal and oral vowels as well as diphthongs and triphthongs. In Portuguese stressed and unstressed syllables are distinguished by the use of vowel height. Portuguese weakens unstressed vowels. That means, that generally, when not stressed, [-back] and [+round] vowels /a, ɐ/, /e, ε/, /o, ɔ/ are

raised to /e/, /i/, /u/. Those unstressed vowels /e, i, u/ are often reduced or voiceless and can be elided in fast speech (Mateus & d'Andrade 2000). This phenomenon is most apparent in post-stressed and final position. For example the word “segundo”, /segundo/ (Engl. ‘second’) becomes /sigundu/ and can even become /sgundu/.

There are also a few exceptions to the rule of reducing unstressed vowels, such as vowels that function as nuclei of closed syllables with an /l/-filled coda and vowels that are part of a syllable whose nucleus contains a glide. (Mateus & d'Andrade 2000).

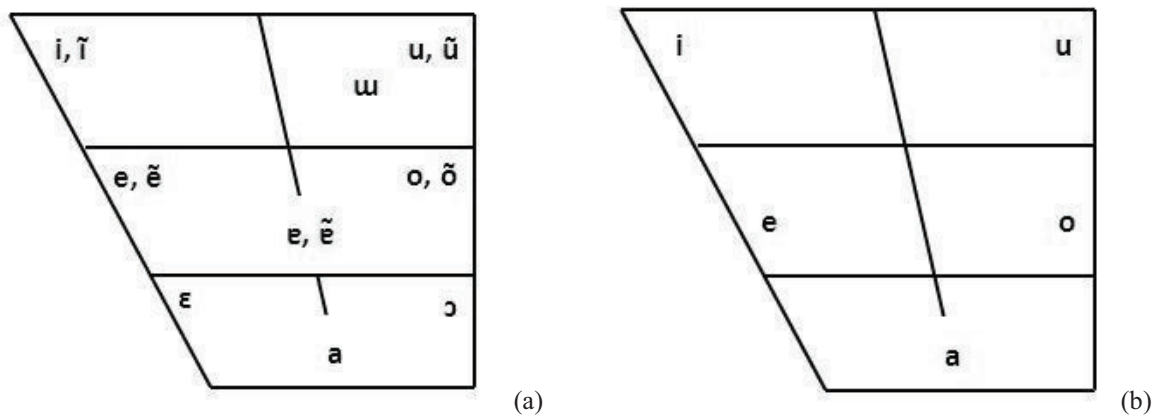


Figure 2: (a) Portuguese vowel system with 14 vowels of which 7 are stressed vowels (Mateus & d'Andrade 2000); (b) Spanish vowel system with 5 vowels (Cressey 1978)

1.2 Speech rate, articulation rate and reduction

When listening to speakers of different languages, we find that some languages sound fast while others are rather slow (Roach 1998). To describe differences in speech rate, Roach (1998) suggests three possibilities: 1. As a natural result of their production, some languages are spoken more rapidly and others more slowly 2. Because of “some sort of illusion” there is an effect of perceiving some languages as spoken more quickly and others more slowly 3. Social acceptance of a preference of rapid or slow speech varies within societies. Those possibilities are influenced by speech rate, articulation rate and the reduction of syllables; these aspects of speech will be introduced in the next paragraphs.

We refer to *speech rate* as the number of elements (syllables, words, etc.) produced per time unit (seconds, minutes, etc.) including pauses. However, it is possible that some languages use more pauses than others and according to Ofuka (1996) our perception of the speed of the language

could be influenced by that. For that reason a different measurement excluding pauses and hesitations has to be used.

Previous studies on speech rate disagree on the definition of a meaningful pause. Campione & Véronis (2002) studied pauses in German, Italian, English, French and Spanish and found that pauses can be as short as 60 ms but also that some pauses shorter than 200 ms are already challenging to distinguish from the silence before an occlusive (Grosjean & Collins 1979). Tsao & Weismer (1997) set the minimal length of such a pause to 150 ms as this is longer than the average stop closure interval and the shortest duration of a 'meaningful pause'.

A measurement excluding pauses is often called *articulation rate*, which is also quantified by the number of entities (syllables, words, etc.) produced per time unit (seconds, minutes, etc.). Thus, articulation rate measures every item a speaker produces in a certain time frame after silent periods were removed.

Another important decision to make when measuring the rate of speech concerns determining the linguistic units as well as the time frame of the measurement. While most studies use seconds as the ultimate temporal measurement (Hilton, Schüppert & Gooskens 2011, Verhoeven, De Pauw & Kloots 2004, Tauroza & Allison 1990), the choice of the linguistic units depends on whether the languages are similar in structure or not. When measuring on a word level, one has to keep in mind that some languages can have very long compound words (eg. German *Donaudampfschiffahrtskapitän*, Engl. 'Captain of a steamboat on the Danube') whereas Chinese for example, has mostly mono- or disyllabic words (Roach 1998). As a result of this discrepancy, most researchers choose to count the number of syllables per second as the most accurate measurement (Roach 1998).

Another variable influencing speech rate is the type of speech. The rate for carefully read out speech, eg. book reading, or reciting a poem is different from spontaneous speech, especially if we are in a hurry or do not want to be interrupted (Fonagy & Magdics 1960). In general, speakers can change their speech rate whenever they deliberately mean to (Trouvain 2004).

Especially in fast speech, there are articulatory processes we refer to as 'reduction'. That is, for example, the elision or lenition of consonants as well as the weakening in the production of vowels (Hilton et al. 2011). To establish the *reduction rate* we subtract the phonetic syllables per time frame from the canonical syllables produced per time frame.

Speech rate and reduction (rate) are interlinked. If the speech rate increases, the reduction rate rises as well because the articulation becomes less clear and syllables are shortened or deleted. A high degree of reduction makes it feasible to pronounce a higher number of syllables in a certain time frame while this increased articulation rate might also be the reason for the increased reduction.

1.3 Previous research on articulation rate and reduction in speech

Speech rate, articulation rate and reduction have been studied by different researchers for various languages and types of speech. In this paragraph we will introduce a few examples including different speech rates within the same language to speech rate measurement of closely related languages

Firstly, Verhoeven et al. (2004) investigated both speech rate (including pauses) and articulation rate (excluding pauses) of the two standard national varieties of Dutch (the Netherlands and Belgium). They found that for both speech rate and articulation rate, speakers of Dutch from the Netherlands spoke 16% faster than speakers of Flemish from Belgium (speech rate: 5.05 vs. 4.23 syllables per second; articulation rate: 4.23 vs. 4.00 syllables per second).

When looking at closely related languages, a study by Hilton, Schüppert & Gooskens (2011) on Danish (6.21 syllables/s), Swedish (5.35 syllables/s) and Norwegian (5.37 syllables/s) shows that Danish has a significantly higher articulation rate.

1.4 Hypothesis

A higher articulation rate might result in a higher syllable reduction in or vice versa. The causality between articulation rate and reduction is not clear. Hilton, Schüppert & Gooskens (2011) conducted a study on Danish, Swedish and Norwegian. These languages are closely related and to a large extent mutually intelligible (Schüppert 2011, Gooskens 2007, Haugen 1966). The authors were investigating whether Danish is more difficult to understand for speakers of the other two languages. The results show that Danish has a significantly higher canonical articulation rate which results in more syllable deletion compared to Swedish and Norwegian, which might make Danish more difficult to understand.

We hypothesize that similar differences are found between Spanish and Portuguese. If this proves to be case, they might be linked to the asymmetry in mutual intelligibility reported by Jensen (1989). More

specifically, the hypothesis for the present study is: Portuguese shows a higher articulation rate which results in a larger number of syllable deletions compared to Spanish.

2. Material and speakers

This investigation aims at comparing articulation rate and syllable reduction in European Spanish and Portuguese. Therefore, comparable material of the two languages had to be used. For the present study the dataset was compiled of radio podcasts from the national radio stations in Spain (www.rne.es) and Portugal (www.rtp.pt). The recordings covered various topics as politics, economics, history, language, cooking, mechanics, art, music, computers, etc. In most cases one speaker prepared a topic, which he or she introduced and then led a discussion about the respective topic. Discussion partners were either invited to the studio or they were speaking on the phone. In contrast to news broadcasts neither the introduction nor the discussion was read out aloud and therefore they were more natural and spontaneous. However, as the speakers had prepared for the topics in advance and more or less knew what they intended to say the recordings might be best classified as semi-spontaneous speech.

The podcasts were aired in February and March 2012 and are free to download from the previously mentioned webpages.¹ All speakers spoke the standard variety from the respective country. The age of the speakers is not known. Table 1 summarizes the total number of recordings, speakers' gender distribution, and total recording time, for Spanish and Portuguese speakers.

The length of the individual recordings varied between 10 and 600 seconds. The recordings were produced by 45 different informants, namely 24 Spanish speakers (12 female, radio station based in Madrid) and 21 Portuguese speakers (10 female, radio station situated in Lisbon). The total recording time for Spanish is 19.18 minutes and 25.95 minutes for Portuguese. To obtain comparable sample sizes, the audio files were cut to be not longer than 40s and recordings shorter than 15s were excluded. In accordance with Tsao & Weismer (1997) pauses longer than 150 ms as well as words that have been repeated (eg. Spanish “lo haremos *como... como...*” [“we will do it *like... like...*”]) and pauses of reflection (eg.: um, eh, etc.) were removed. Also, recordings of dialogue partners, either in the studio

¹ We received the permission from the radio station to use the podcasts for non-commercial research.

or present on phone have been excluded. This eventually rendered a total time of 13.5 minutes for the Spanish and 13.2 minutes for the Portuguese recordings.

Table 1: Number of recordings as well as gender distribution of the analyzed speakers and total recording time across languages

Language	N	Female	Male	Total recording time (before cut) in min.
Spanish	24	12	12	19.18
Portuguese	21	10	11	25.95

3. Measurements

In most studies, articulation rate has been measured by counting the number of syllables per second (Verhoeven et al. 2004). Yet, to measure reduction, a clearer distinction has to be made. Hildebrandt (1963) was the first to make a distinction between the intended form (canonical form) and the realized form (“effective number of sounds”).

To establish the canonical articulation rate, syllables were counted manually by native speakers of Spanish and Portuguese based on orthographic transcriptions of the recordings. In addition the duration in seconds of every sequence was established. The rate of canonical syllables per second was calculated by dividing the number of canonical syllables per speaker by the duration of the utterance.

To establish the phonetic (realized form) articulation rate, we used a script that was developed for PRAAT (Boersma & Weenink 2008) by De Jong & Wempe (2009). This script automatically marks and counts phonetic syllables by identifying the number of intensity peaks in the speech that has voicing. We then defined a peak as an intensity drop of at least 2dB right before and after the peak. According to De Jong & Wempe (2009) the automatically measured speech rate significantly correlates with manually measured speech rate ($.71 < r < .88$). After Running the PRAAT script for each utterance, we received an output of marked and counted intensity peaks. No correction by hand was conducted afterwards.

Identical to the canonical articulation rate, the phonetic articulation rate was established by dividing the number of automatically counted syllables by the length in seconds of the recorded utterance.

Figure 1 shows the oscillogram, spectrogram and phonetic syllable tier for the Spanish fragment *En España el congreso ha aprobado* (Engl.: ‘In Spain the congress has approved’). The canonical syllable count for that fragment is 13 (en-Es-pa-ña-el-con-gre-so-ha-a-pro-ba-do) while the automatic phonetic count detects 10 syllables.

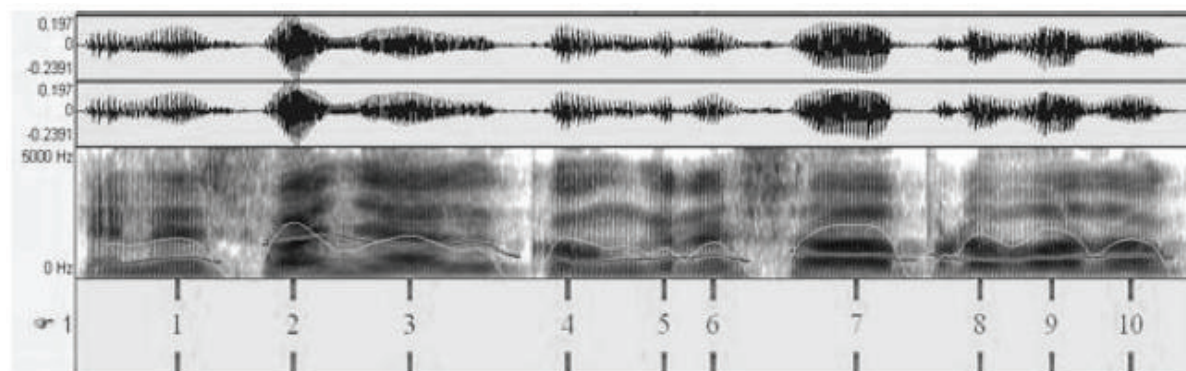


Figure 1: Oscillogram, spectrogram and phonetic syllable tier for the (1.55s) Spanish fragment *En España el congreso ha aprobado* (13 canonical syllables), automatic phonetic syllable count: 10. The thin white line traces the intensity.

Figure 2 shows the oscillogram, spectrogram and phonetic syllable tier for the Portuguese example fragment *De acordo com a proposta do governo* (Engl.: ‘According to the proposition of the government’). The canonical syllable count for that phrase is 13 (de-a-cor-do-com-a-pro-pos-ta-do-go-ver-no) while the automatic phonetic count detects only 8 syllables.

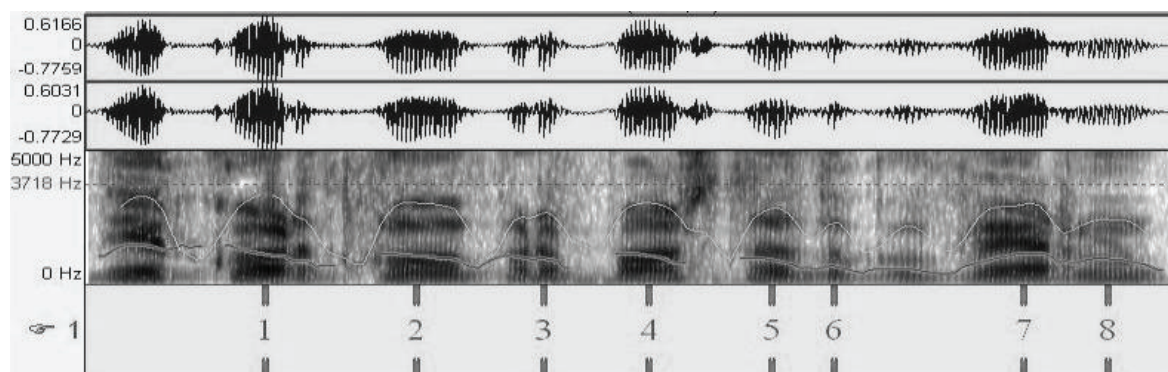


Figure 2: Oscillogram, spectrogram and phonetic syllable tier for the (1.40s) Portuguese fragment *De acordo com a proposta do governo* (13 canonical syllables), automatic phonetic syllable count: 8. The thin white line traces the intensity.

4. Results

4.1 Canonical syllables

Table 2 gives total utterance length, number of canonical syllables and canonical articulation rate per language. On the canonical level, Spanish speakers speak as fast as Portuguese speakers in a particular time unit. That means both convey the same amount of semantic information in the same time.

An independent sample *t*-test was conducted, comparing speakers' mean rate of canonical syllables per second (Portuguese: $M = 6.60$, $SD = .75$; Spanish: $M = 6.50$, $SD = .75$). The *t*-test showed no significant difference between the two languages ($t(43) = .25$, $p = .64$).

Table 2: Utterance length, number of canonical syllables and canonical articulation rate for Spanish and Portuguese

Language	Utterance length (s)	No. of canonical syllables	Articulation rate (canonical syllables/s)
Spanish	813.8	5284	6.50
Portuguese	818.6	5411	6.60

4.2 Phonetic syllables

Table 3 shows total utterance length, number of phonetic syllables and phonetic articulation rate per language. On the phonetic level, Portuguese speakers transmit a higher amount of phonetic information per second compared to Spanish speakers.

Table 3: Utterance length, number of phonetic syllables and phonetic articulation rate for Spanish and Portuguese

Language	Utterance length (s)	Number of phonetic syllables	Articulation rate (phonetic syllables/s)
Spanish	813.8	3512	4.32
Portuguese	818.6	3135	3.94

An independent *t*-test showed that the phonetic articulation rate is significantly ($t(43) = 0.02$, $p = 0.01$) lower for the Portuguese sample ($M = 3.95$, $SD = .34$) than for the Spanish sample ($M = 4.32$, $SD = .57$).

4.3 Reduction

To establish the difference between canonical and phonetic syllables, that is, to find out if the degree of reduction is larger for Spanish or Portuguese, the reduction rate was calculated by subtracting the number of phonetic syllables from the number of canonical syllables per second (Table 4). The reduction rate for Spanish is 2.18 syllables per second, while Portuguese showed a significantly ($M = 2.65$, $SD = .623$): $t(43) = .229$, $p = .040$) higher reduction of 2.66 syllables per second. That means that Portuguese speakers use fewer but longer syllables to transfer the same information as Spanish speakers.

Table 4: Canonical articulation rate, phonetic articulation rate and reduction rate of Spanish and Portuguese

Language	Articulation rate (canonical syll/s)	Articulation rate (phonetic syll/s)	Reduction ratio (canonical syll/s - phonetic syll/s)
Spanish	6.50	4.32	2.18
Portuguese	6.60	3.94	2.66

5. Discussion and conclusion

The present study investigated articulation rate of Spanish and Portuguese, both on the phonetic and canonical level. To that end, we collected audio data of podcasts from the respective countries, adjusted the file length, removed pauses, counted canonical syllables and had a PRAAT script (De Jong & Wempe 2009) count the phonetic syllables (intensity peaks). The canonical and phonetic articulation rates were established by dividing the number of syllables by the length of the utterance (syllables per second). The reduction rate was calculated as the difference between the canonical and the phonetic articulation rate. Slightly contrasting with

our hypothesis, we found that Portuguese shows indeed the same canonical but a lower phonetic articulation rate compared to Spanish.

Furthermore, the syllable reduction rate of Portuguese was significantly higher than the Spanish syllable reduction rate. However, contrary to earlier studies on syllable reduction (Hilton, Schüppert & Gooskens 2011), on Scandinavian languages, we did not find a significant difference between the language's canonical articulation rate but rather between the phonetic articulation rate. The implications of our results will be discussed in the following sections.

5.1 Articulation rate in Spanish and Portuguese

The lack of a significant difference in canonical articulation rates of Spanish and Portuguese, and the fact that both languages are structurally very close, indicates that an equal amount of semantic information per second is transferred in fluent speech in both languages. On the perception level, that means that Portuguese and Spanish listeners have the same amount of time to understand the message expressed in the other language.

Comparing the results of the automated count of intensity peaks of the same recordings of fluent speech in Spanish and Portuguese, we noted a significant difference in the number of phonetic syllables per second. Phonetically, Portuguese speakers produced 0.38 syllables less per second than speakers of Spanish. This indicates that phonetic syllables in Portuguese probably carry more phonetic information individually than Spanish ones, for they are more likely to have more phonemes. Thus, Portuguese syllables contain more complex consonant clusters.

5.2 Reduction rate in Spanish and Portuguese

To measure the elision of syllables in fluent speech, the reduction ratio was established by subtracting the total number of phonetic syllables per second from the total number of canonical syllables per second. Following this procedure, we were able to demonstrate that both Spanish and Portuguese exhibit a certain degree of reduction. Portuguese speakers, however, deleted significantly more syllables per second. These results indicate that canonically Portuguese speakers per se do not speak faster than Spanish speakers, but reduce more syllables. On one hand, we conclude that Portuguese speakers eventually produce longer but fewer syllables per second. On the other hand, Spanish speakers reduce less and therefore produce a larger number of consonants and vowels per time unit than Portuguese

speakers. Those phenomena make Spanish sound fast while Portuguese is perceived as rather slow.

Our results are in contrast with Hilton et al. (2011), who examined phonetic and canonical articulation rates between Danish, Swedish and Norwegian. They report significant differences for canonical, but not for phonetic articulation rates. In our study we found the opposite pattern. Spanish and Portuguese showed no noticeable difference in regard to the canonical articulation rate while the phonetic articulation rate differed significantly between the two languages. These, seemingly contradictory, results will be discussed in the following paragraphs.

The outcome implies that speakers of Danish actually transfer more information per second than speakers of the neighboring languages, thus showing a higher canonical articulation rate (and a higher reduction rate), while Spanish and Portuguese speakers do transfer the same amount of information but Portuguese speakers reduce more syllables per second.

One of the reasons for a higher syllable reduction in Portuguese might be the fact that in Spanish mostly only consonants are reduced while in Portuguese vowels as well as consonants can be reduced. In post-stressed and final position, unstressed Portuguese vowels /e, i, u/ are often reduced or voiceless and can be elided in fast speech (Mateus & d'Andrade 2000). This phenomenon gives more possibilities for syllable reduction in general.

Another possibility to explain the lower reduction rate for Spanish might be found through isochrony. Spanish is more syllable-timed, or according to Dauer (1983), further away from being stress-timed than Portuguese is (see Section 1.1). For syllable-timed languages each syllable has to have more or less the same length which makes reduction for Spanish, in general, less possible.

5.3 Possible effects on mutual intelligibility

The higher syllable reduction rate of Portuguese might be a factor, which causes or boosts the asymmetry in mutual intelligibility found by Jensen (1989). In the present study we showed that speakers of European Portuguese do not speak faster per se but due to vowel elision Portuguese shows more reduction, which might make it less intelligible.

On the perception level, the Portuguese listener receives more phonetic information in Spanish, which means that the he or she has to work harder to process all the phonemes in the same amount of time. This however should not be too difficult for Portuguese speakers as there is

hardly any reduction or elision in Spanish and all the vowels and almost all the consonants in the Spanish inventory are also present in the Portuguese vowel/consonant inventory (Figures 2a and 2b). For the Spanish listeners, however, the exact opposite takes place. Theoretically they have more time to decode the few phonemes in the message, but the fact that (too) many sounds are elided and that Portuguese has a much more varied vowel inventory than Spanish make it difficult for Spanish speakers to firstly identify the right sounds in order to secondly identify possible cognates.

Linguistic variables, such as phonetic features, and in this case reduction rate, can be predictors for intelligibility of closely related languages. We hypothesize that speakers of European Spanish understand European Portuguese to a lesser extent than vice versa. This hypothesis will be tested in a future experiment.

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