An Acoustic Study of Word-Initial Stops by Catalan/Spanish Speakers

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1. Introduction

"Pronunciation corresponds to one of the key elements that influence the mastery of a language" (Alves & Magro 2011: 72). Whenever someone learns a second language, he or she might find that L2 classes are focused only on the four skills of reading, writing, listening and speaking. Pronunciation plays an important role in L2 acquisition but it is always forgotten due to the fact that it is an element that requires time and expertise to be properly taught.

The aim of this paper is to focus on L2 pronunciation and particularly, on the implementation of the voiced-voiceless contrast in English stops by investigating the production of aspiration in word-initial position by Catalan/Spanish speakers of English.

Fullana and MacKay (2008) state that the production of English aspiration is a difficult aspect for a great majority of native speakers of Romance languages because of the fact that it is produced in a totally different way in English and in Catalan/Spanish. As a result of this, and due to the few number of studies on this particular topic in which Catalan/Spanish speakers are involved in, I found it interesting to investigate how undergraduate students at the Universitat Autònoma de Barcelona produce English aspiration and how explicit teaching of this feature may help them improve their pronunciation.

Thus this paper will also take into consideration an important external factor: the phonetics and phonology course offered by the degree.

This study addresses the following research questions:

1. How are English VOT values for /p, t, k/ produced by Catalan/Spanish undergraduate learners of English?

2. Which is the effect of explicit instruction on the production of English voiceless plosives, /p, t, k/, in word-initial position by Catalan/Spanish learners?

2. Literature Review

Background

Languages vary from one another in many respects; they all have different inventories of sounds and a large number of features that allow them to be distinguished from the rest. Nevertheless, voicing is one of the most common features that many languages share, and it makes a distinction between voiced and voiceless phones (Liberman et al., 1958; Lisker and Ambramson, 1970). Voicing is the specific feature under investigation in this acoustic study that underlies one of the problematic phonological areas for Catalan/Spanish learners of English affecting stop consonants, known as VOT (Fullana & MacKay, 2008; Suárez, 2008).

English stop consonant phonemes are /p b t d k g/ and what they all have in common is the fact of sharing a momentary blockage of the vocal tract at some point of their production. As a result, depending on the place of the articulatory occlusion, they can be classified into three different groups: bilabial /p b/, alveolar /t d/ and velar /k g/. Kent and Read (1992: 106) provide an articulatory and acoustic classification of stop consonants, as is illustrated in Figure 1.

These researchers make a distinction between those stop consonants that are found in syllable-initial position, which have a closure phase first, a release phase secondly and the transition at the end; and those stops that are found in syllable-final position, which have first the transition, then the closure phase and finally they might or might not have the release phase. This research paper focuses on the upper part of the diagram, particularly on word-initial stops with releases that can be classified as aspirated or unaspirated.

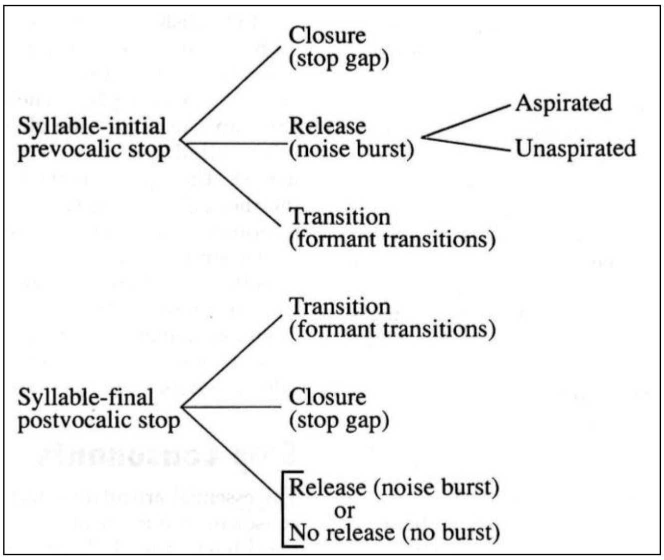

Figure 1. Phonetic classification of stop consonants

'Aspiration is a breathy noise generated as air passes through the partially closed vocal folds and into the pharynx' as Kent and Read (1992: 106) state. Hence, unaspiration, as the prefix indicates, takes place when this breathy noise is absent in the pronunciation of some stop consonants. In English, there are three voiceless stops /p t k/ that are aspirated whenever they are found at the beginning of a stressed syllable or at the beginning of a word. Figure 2, by Kent and Read (1992), illustrates two different spectrograms. In the first one, the interval of aspiration is shown by means of an arrow and, in this case, one can observe that aspiration appears between the stop gap and the formant transitions. Nonetheless, the second spectrogram shows an unaspirated stop consonant; the interval of aspiration that can be found in A cannot be observed in B. Thus, in the second spectrogram one can see that the onset of vocal fold vibration begins really close to the burst; hence there is none or a slightly opportunity for an interval of aspiration to occur.

The concept of aspiration leads one to introduce Voice Onset Time (VOT). Positive VOT is defined according to Ladefoged (2012: 120) as ‘the interval between the release of a stop and the start of the following vowel’. Thus, the left panel in Figure 2 shows a long VOT for the aspirated stop, whereas the right panel shows a very short VOT – i.e., vocal fold vibration starts almost at stop release – for the unaspirated stop.

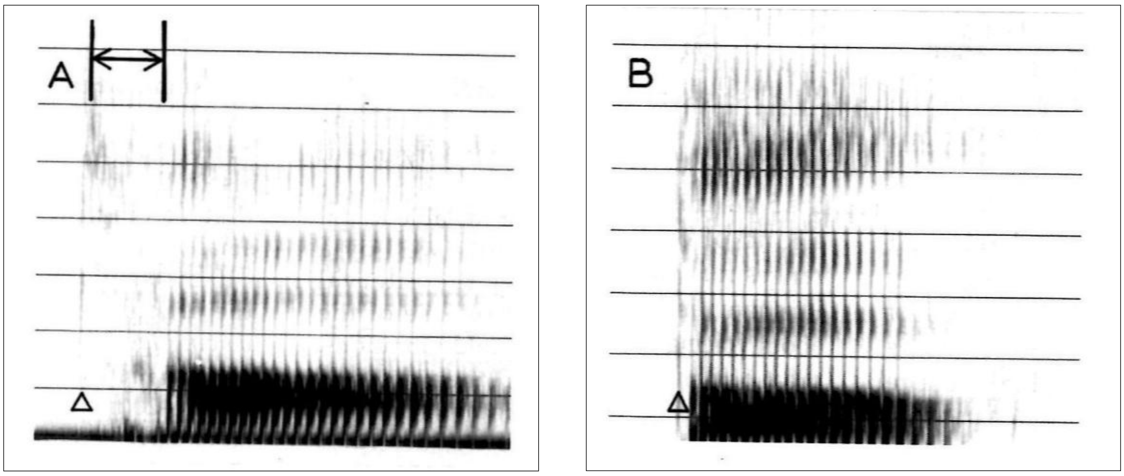

Figure 2. Spectrograms for aspirated (A) and unaspirated (B) stops.

Lisker & Abramson (1964) carried out a cross-linguistic study of Voice Onset Time, in which they studied a total of eleven different languages in order to examine whether VOT was able to separate and differentiate the stop categories. They studied VOT by just looking at word-initial stops followed by vowels in isolated words and in running speech. Lisker and Abramson described three major VOT types, and they concluded that VOT was found to be ‘highly effective as a means of separating phonemic categories’ (422) among those languages that they examined. Furthermore, they made a broad generalisation about how to group the languages they studied, and finally, they ended up by classifying the eleven languages according to their distribution of voice onset time, as presented in the next section.

As a result, before elaborating on the classification of languages according to their VOT values, it is important to distinguish between three types of VOT. Whenever the VOT is zero, this means that one is dealing with an unaspirated stop because voicing starts at the time of release. Whenever there is positive VOT, the release occurs first and vocal fold vibration starts at a later point in time; this is known as voicing lag. However, it is important to distinguish between two types of voicing lag. On the one hand, there is going to be short voicing lag whenever small positive values of VOT are found (e.g., VOT = 0-25 milliseconds); on the other hand, there is going to be long voicing lag whenever large positive values of VOT are found (e.g., VOT = 25-100 ms). Finally, the last type is negative VOT, meaning that voicing starts before the release (that is, during the consonant constriction); hence it is called voice lead (González-Bueno, 1997; Alves & Magro, 2011). The VOT ranges for voiced and voiceless stops are illustrated in Figure 3.

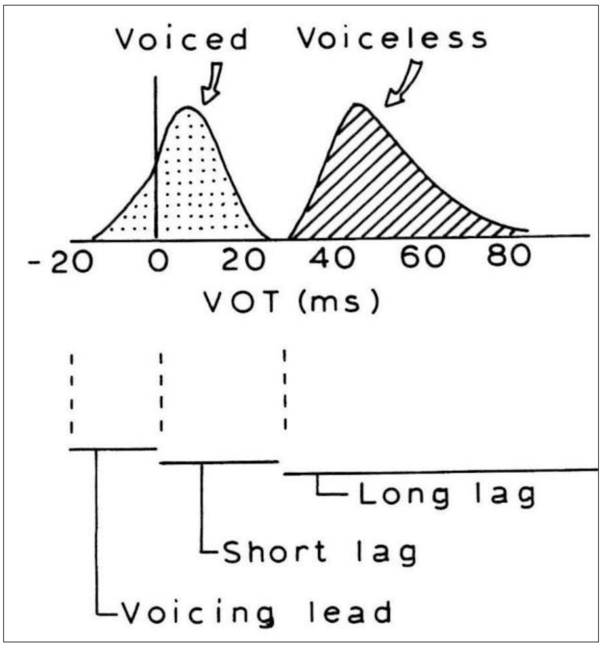

Figure 3. Different types of voice onset time (VOT). Taken from Kent and Read

Differences in the production of stops in English and Spanish

According to the distribution of VOT values, one can make a broad classification of different languages depending on whether they use presence or absence of aspiration to indicate the voicing contrast in stops, or presence or absence of voicing during the stop. Many researchers on the topic, such as Ladefoged (2012), made a distinction between Germanic and Romance languages:

> 'In general, Germanic languages like English, German and Danish have comparatively long aspiration interval (i.e. long VOTs); these languages contrast voiceless or only weakly voiced stops with aspirated stops. In Romance languages like French and Spanish, the voiceless stops have virtually no aspiration, and the contrast is between fully voiced stops and voiceless stops.' (139).

This is clearly illustrated in Figure 4 (from Ladefoged (2012: 138). Figure 4 shows the production of some stop consonants in Spanish and English. As it can be observed in the Figure, there is a table in which a comparison of English /b/, /p/ and Spanish /b/, /p/ is made in order to support the existing classification among languages according to their VOT. In addition, waveforms of the Spanish and English words are also presented in the lower part of Figure 4. As it is reflected, Spanish voiced stops /b d g/ are prevoiced because voicing begins during the stop closure, before the stop release, resulting in negative VOT, as illustrated in *besos*. Spanish voiceless stops /p t k/, on the other hand, are produced with a near-simultaneous release and beginning of voicing, resulting in positive short lag VOT values, between 0 and 25 milliseconds, as shown in *pesos*. In contrast, English voiced stops /b d g/ are not prevoiced like in Spanish but released at the same time that voicing begins, resulting in a positive short lag VOT values between 0 ms and 25ms, as it is observed in *bases*. Finally, English voiceless stops /p t k/ have a long delay between the release and the beginning of voicing, resulting in positive long lag VOT values of 25 ms or longer, as it can be seen in *paces*. (Lisker and Abramson, 1964; Cho and Ladefoged, 2000, Benkí, 2005).

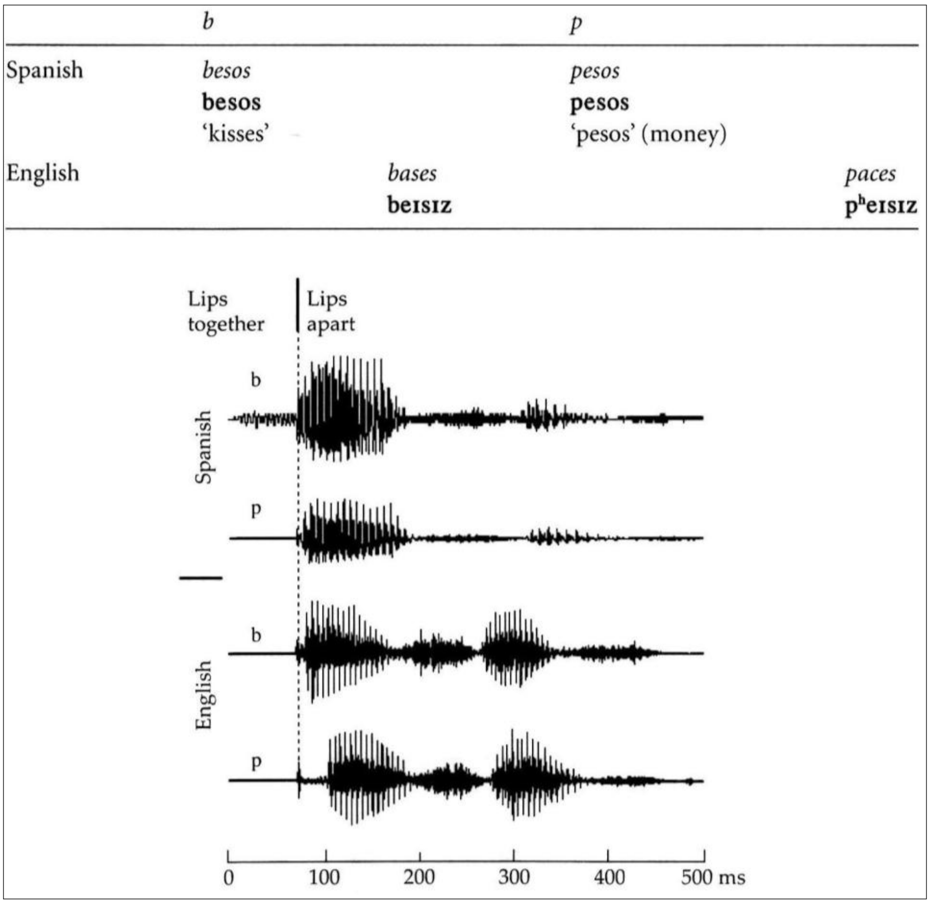

Figure 4. Voicing and aspiration of Spanish and English words and its waveforms

L2 Phonological Acquisition

As Lord (2010) states 'within the realm of L2 phonology there are multiple avenues of investigation, such as the acquisition of vowels, consonants, and suprasegmental features' (489-490), and acquiring a second language phonology (L2) is a really complex process. Therefore, the aim of this study is to focus on the production of L2 sounds by Catalan/Spanish speakers of English. Most of the current literature concerning the production of L2 sounds has been carried out from an English perspective, in which these L2 sounds were produced by English-speaking learners of Spanish (González-López, V. & Counselman, D., 2013), or other L1 learners of English, such as Brazilian Portuguese and Japanese (Alves & Magro, 2011; Ekelund, 2011). Currently, just a few studies on how Catalan/Spanish speakers of English produce L2 sounds have been carried out (Fullana, N. & MacKay, Ian R. A, 2008).

The fact that languages have different phonological systems and different phonemic categories, which might pose some difficulties to those non-native speakers, has been a matter of concern in theories of L2 acquisition, such as Best's Perceptual Assimilation Model (PAM) and Flege's Speech Learning Model (SLM). Best (1995) proposed a model which describes that the difficulty in learning L2 speech is influenced by how second language learners perceive L2 sounds and assimilate them to their L1 categories. In other words, when L2 learners of a particular language listen to L2 sounds, they classify them into different categories depending on the degree of articulatory-phonetic similarity and /or discrepancy perceived between the native and L2 sounds. Nonetheless, according to Flege's Speech Learning Model (1995), the closest the L1 and L2 sound are, the more difficult it is to perceive the differences between them and produce the L2 sound correctly. Thus, due to the interaction between L1 and L2, similar L2 sounds or segments will be assimilated to native categories, whereas, new L2 categories will be created over time whenever different L2 sounds or segments are found.

Flege and Eefting (1987) focused on how Spanish children and adult speakers from Puerto Rico produced and perceived English stops in initial position. These new phonetic categories are not as authentic as the native English ones because the 'similar' L2 stops are considered to be realizations of the same category as the L1 sound . As a consequence, L2 learners tend to produce sounds that are neither L1 nor L2 but share features of both. Flege and Eefting (1987) concluded their paper by saying that producing a second language in an appropriate and almost native way might depend on several aspects, such as the age-factor, the degree of literacy and the quality of input.

Turning to the role of input, the phonetic input received during the acquisition of the L2 can be grouped in two types: the one received by immersion in the target language community, or by explicit instruction (Lord, 2010). The current acoustic study is going to focus on a particular phonetic instruction course and its effects on the production of English aspirated stops.

Many researchers have carried out acoustic studies by observing whether receiving phonetic instruction of the L2 makes L2 learners improve their pronunciation or not (Suárez, 2008; Lord, 2010; Alves & Magro 2011). Alves & Magro (2011) examined how Brazilian Portuguese speakers acquire and produce English aspiration for the voiceless phoneme /p/. They report that the role of explicit instruction on how to pronounce aspirated /p/ in word-initial position in English was a really good choice in order for Brazilian Portuguese speakers to acquire English aspiration. Furthermore, they concluded the paper by stating the presence of an instruction course in phonetics has been successful among the L2 learners and positive effects on their abilities to produce L2 sounds more accurately have been found. The present study attempts to provide further evidence for the role of explicit phonetic instruction in Catalan/Spanish learners of English.

3. Methodology

3.1. Research Questions

The research questions that guided this acoustic study were the following:

1. How is aspiration of /p, t, k/ produced by Catalan/Spanish learners of English?

2. Which is the effect of explicit instruction on the VOT values of English word-initial /p, t, k/?

Previous studies, and in particular Lisker and Abramson (1964), found that Spanish voiceless stops show short positive VOTs for /p, t, k/ whereas English stops involve long positive VOTs. It is hypothesised that Catalan/Spanish-speaking learners of English will produce shorter values of VOT for English voiceless stops (i.e., less aspirated; hence more Catalan/Spanish-like) than native English speakers. Furthermore, a more native-like production of aspirated stops (i.e., longer VOT values) is expected after explicit instruction in a course on English phonetics and phonology.

The explicit instruction course on English Phonetics and Phonology is offered to second-year undergraduate students and it consists of an introduction to the principles of general phonetic description and taxonomy from an articulatory point of view. A description of the sounds of English is provided and students practice hearing and producing the linguistically relevant differences in English, such as aspiration. Two 1,5 hrs sessions are dedicated to describing VOT, using line drawings; differences in VOT in English and Spanish/Catalan stops are described, and the role of aspiration to cue the voiced-voiceless contrast in English stops in emphasised. This is followed by extensive practice with minimal pairs and sentences. The practice of aspiration is reinforced throughout the course and feedback is provided when adequate.

3.2. Participants

In order to conduct this acoustic study, a total of 16 participants were asked to take part in the experiment. The participants were undergraduate English Studies majors at the Autonomous University of Barcelona (UAB). Two different groups of students were analyzed. The first group consisted of 8 first-year students, (average age 18); and the second group consisted of 8 students in their second year (average age 20). The main difference between the two groups was that second-year students had taken as 'English Phonetics and Phonology' course with explicit instruction on the role of aspiration in English.

In order to select the subjects for the acoustic experiment, a language background questionnaire was distributed to all the first and second-year undergraduate students in order to know the ones that met the requirements for the study. The selection of subjects attempted to control for a number of potential confounding variables.

The selection of these two groups of undergraduate students was based on their university examination marks. In the case of the first-year participants, the marks obtained in the course *Usos Bàsics de la Llengua Anglesa* were the basis to select the appropriate students. In the case of the second-year participants, the marks obtained in the course *Phonetics and Phonology I* were the basis for the subject selection.. It should be pointed out that in the case of the latter group, some specific examinations of the phonetics and phonology course, such as the oral assignment and the final oral exam, were also taken into consideration when selecting the participants. In both groups students who scored between 70-80% on a 100% scale were selected for this acoustic study.

Another crucial requisite was that subjects had not been abroad, and, therefore, in an English-speaking environment for a long period of time. None of the participants had been in an English-speaking country in their life, and the ones that did, spent no more than 3 weeks in summer.

Another requirement that the selected undergraduates needed to meet was that the language of instruction at Elementary, Primary and Secondary school was not English but Catalan and/or Spanish. In addition, half of the subjects in each group had started learning English at Elementary school for 3 hours a week (n=8), and the other half started when they were at Primary school for also 3 hours a week (n=8). In addition, it is interesting to point out that subjects in both groups went to English classes outside the school with the exception of 3 in Group 1 and 2 in Group 2. Finally, the last requirement that the participants needed to fulfil was not having any English-speakers, such as partners, parents, in-laws, as family members, which none of the participants did.

Requirements	**Group 1**	**Group 2**
Academic year	1st	2nd
Having taken the phonetics and phonology course	**NO**	**YES**
Proficiency level of English (out of 100%)	70-80%	70-80%
Linguistic experiences abroad	3/8 (maximum 2 weeks)	3/8 (maximum 3 weeks)
Language of instruction at Elementary, Primary and Secondary school	Catalan/Spanish	Catalan/Spanish
English starting-age (average)	4’6	5’8
Extra English classes	5/8	6/8
Family English-speakers	NO	NO

Table 1. Necessary requirements

Further information concerning the participants’ English language use, experience and exposure was also obtained and was ensured to be comparable in the two groups.

3.3. Elicitation material and procedures

The 16 subjects (8 in each group) were recorded reading English words in a carrier phrase and English sentences.

The reading material consisted of a list of 18 words (9 minimal pairs) and 4 sentences containing voiced and voiceless stops in word-initial position. In this position, voiceless stops are aspirated whereas voiced stops are typically unaspirated and they may or may not have voicing.

	/p/	**/b/**	**/t/**	**/d/**	**/k/**	**/g/**
/ɪ/	Pin	Bin	Tin	Din	Kit	Git
/e/	Pen	Ben	Ten	Den	KET	Get
/æ/	Pat	Bat	Tan	Dan	Cap	Gap

Table 2. List of minimal pairs used in the experiment.

The minimal pairs involving bilabial, alveolar and velar stops were organised in 3 different sets, in which each of them contained a different vowel. The first set of tokens contained [ɪ], a high-mid and front vowel; the second one [e], a mid and front vowel; and the third set of tokens contained [æ], a low and front vowel. The 18 words were presented in random order, as shown in appendix 8.1 (Test), so that subjects did not guess the purpose of the experiment. All words (except one, KET) were real English words, known by the subjects.

Different vowels were tested because the height of the vowel is expected to affect aspiration (Yavas 2009). Aspiration has been shown to be longer before high rather than low vowels. Consequently, this factor was taken into account in this study.

All 18 words were monosyllables and they were read five times each in the carrier phrase '*Say* _______ *twice'*.

The second part of the experiment consisted of reading 4 sentences containing voiced and voiceless stops five times each. One word began with /p/, four with /t/, and two began with /k/; three words were distractors that began with /s/ followed by /p/ and /t/ (see Appendix 8.1, 2).

3.4. Analysis procedure and Acoustic Analysis

The recordings were made using a digital voice recorder and a unidirectional microphone in the phonetics laboratory. Acoustic measurements of the duration of aspiration before different vowels were made using Praat (a voice analysis software program). Waveforms and spectrograms were used to measure VOT.

Individual tokens of word-initial aspirated stops [p^h, t^h, k^h] were identified on the spectrograms. Aspiration was measured from the release burst of the stop to the first regular vibration of the vocal folds. The average of duration of aspiration for each voiceless stop [p^h, t^h, k^h] before high, mid and low vowels was calculated for each speaker and group (first and second years). Finally the standard deviation (SD) was calculated and the mean duration of aspiration and SD was plotted for each group of speakers using a bar graph.

VOT for voiced stops was also measured for comparison, and values are reported in the results section. However, due to the focus of the study and space limitations, only the results for voiceless stops will be analyzed here.

Two-factor ANOVAs were used to assess the significance of the results.

4. Results and discussion

Figure 5 shows the mean VOT values for minimal pairs across consonant place and vowel type for voiced and voiceless stops for first and second-year English L2 learners, and for native speakers of English. The mean values for native speakers are taken from Lisker and Abramson (1964) (the standard deviation is not available). The mean VOT value for voiceless stops is 38,96ms (SD=9,96) for the first-year group, 57,15ms (SD=12,32) for the second-year group and 69,33ms for the English native speakers. The table also shows that the VOT mean for English voiced stops is -68,93ms (SD=18,70) for the first-year group, -34,05ms (SD=17,82) for the second-year group and 14ms for the native speakers of English. Although this study does not focus on voiced stops, it is worth noting that whereas native English speakers tend to devoice word-initial voiced stops (i.e., they show no voicing during the closure and short voice lag), both first and second year students show fully voiced stops.

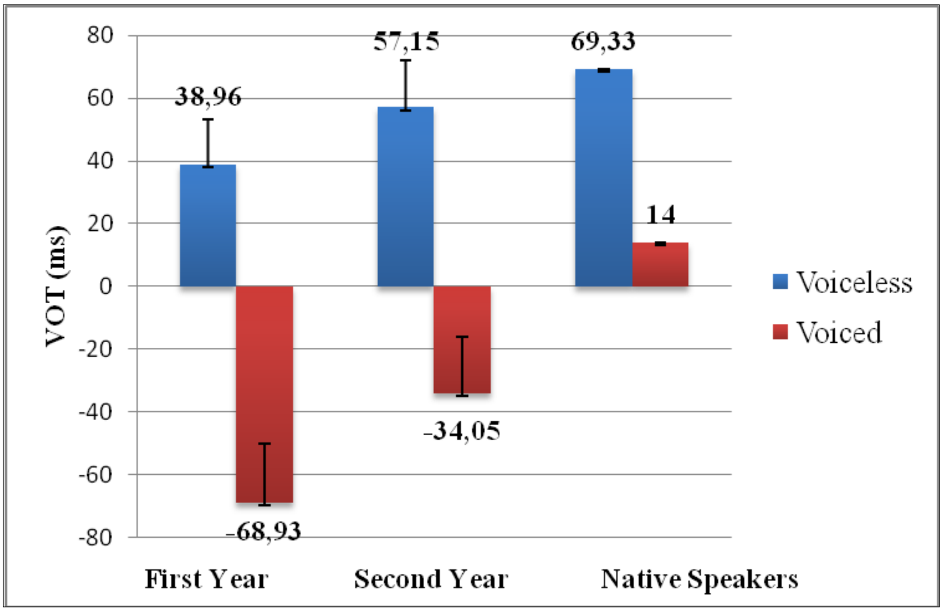

Figure 5. Mean VOT values for voiced and voiceless stops averaged across minimal pairs and sentences.

As stated in the Methodology section, the test had two parts; the first one involved reading words in a carrier phrase, and the second one reading sentences that contained a variety of word-initial stops. Figure 6 presents the results obtained from the first exercise (minimal pairs); and the Figure 7 presents the results obtained from the second part of the test (sentences).

Figure 6 (minimal pairs) reveals that the mean VOT value for /p, t, k/ for first-year participants is 26,46ms (SD=9,75) for labials, 45,06ms (SD=10,46) for alveolars , and 45,37ms (SD=10,23) for velars. But most importantly, there is a longer period of aspiration for second-year participants compared to first-years, with the VOT value for /p, t, k/ being 41,94ms (SD=13,96), 61,57ms (SD=11,09), and 67,95ms (SD=11,34) respectively.

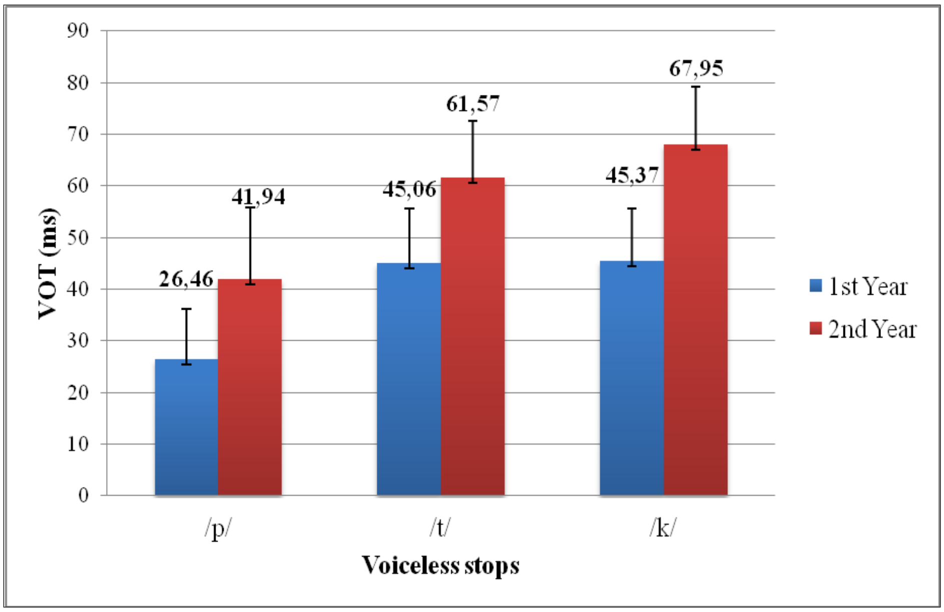

Figure 6. Mean VOT values for voiceless stops (minimal pairs)

Figure 7 (sentences) shows that there is a slight variation in terms of aspiration in comparison with Figure 6 (minimal pairs). The VOT value for /p, t, k/ is 20,02ms (SD=8,99), 43,76ms (SD=8,88), and 48,56ms (SD=10,35), respectively, for first-year students. Again, the Figure shows that there is an increase in duration of aspiration for second-year students, the mean VOT values being 30,72ms (SD=15,54), 52,41ms (SD=11,98), and 60,63ms (SD=11,34) for /p t k/ respectively.

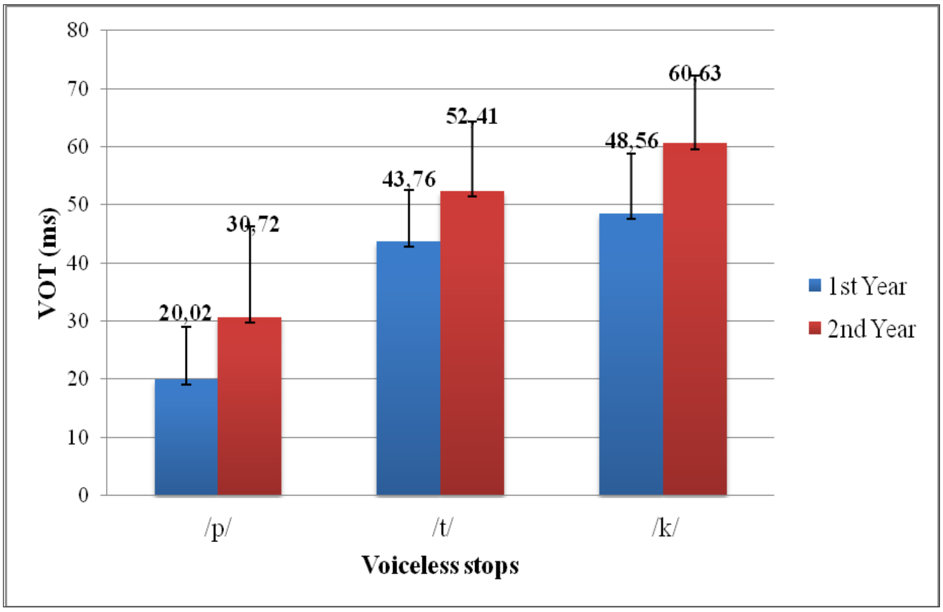

Figure 7. Mean VOT values for voiceless stops (sentences)

A two-factor ANOVA with Phonetics Course (first-year students without exposure to a phonetics course vs. second year students with exposure to a phonetics course) and Reading Material (minimal pair vs. sentences) as the independent variables was performed on VOT values.

The ANOVA revealed a very significant Phonetics Course effect ($F [1, 1436] = 106{,}80$, $p < 0{,}01$), with duration of aspiration being significantly longer in second-year participants compared to first-years (52,53 vs. 38,20 ms). There was also a significant Reading Material (minimal pairs vs. sentences) effect ($F [1, 1436] = 4{,}26$, $p < 0{,}05$), indicating that duration of aspiration differs as a function of reading minimal pairs (48,05ms) or sentences (42,68ms). Finally, the results show a very significant Phonetics Course by Reading Material interaction ($F [1, 1436] = 8{,}60$, $p = 0{,}003$), indicating that the differences in duration of aspiration that exist between both groups of participants vary with the reading material in which voiceless stops are found (or vice versa). The line graph in Figure 8 illustrates the interaction between the two factors, such that first-years did not show a difference between the two types of material whereas second years did, in line with behaviour by natives speakers (Labov 2006).

These results further illustrate that features of pronunciation may differ depending on the type of material used in linguistic studies. In other words, stylistic variation, which makes reference to the variation in the speech of individual speakers, will be different according to the type of material that participants might encounter. Stylistic variation is illustrated by Labov's (1972) study of New York City English in which he pointed out that producing words in a minimal pair context tends to elicit the most careful and formal speech style. Thus, participants are going to pay more attention to the word contrasts, as it is reflected in the case of the minimal pair production by the second-year group. However, when producing words in a meaningful sentence, participants are less likely to pay attention to potentially contrastive words, and hence, they are going to produce them in a more natural, less overarticulated way. This is precisely what is found in our second-year students.

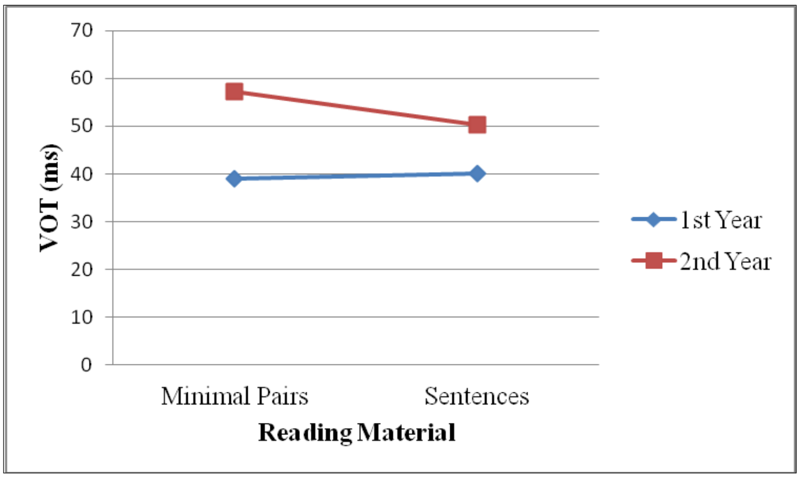

Figure 8. Interaction Effects between Phonetic Course and Reading Material

Having analysed the differences between the two types of reading material, minimal pairs and sentences, the rest of the analysis will focus on minimal pairs only given that consonant place of articulation and vowel type were controlled for in this material.

We now turn to differences in aspiration for consonants at different places of articulation. VOT values for first and second-years broken down by consonant place are presented in Figure 6. The Figure shows that for both groups, labials have a shorter duration of aspiration (M=20,02ms and 30,72ms) than alveolars (M=43,46ms and 52,41ms) and velars (M=48,56ms and 60,63ms). In order to assess if these differences were significant, a two-factor ANOVA with Consonant Place and Phonetics Course on VOT values was performed.

The ANOVA showed a very significant Place of Articulation effect ($F [2, 174] =57$, $p < 0,01$), indicating that duration of aspiration differs with place of articulation of the consonant (/p/ = 34,2ms, /t/ = 53,31ms, /k/ = 56,66ms). The further back the place of articulation of the consonant, the longer the period of aspiration. There was also a very significant Phonetics Course effect ($F [1,714] = 90,64$, $p < 0,01$), with duration of aspiration being significantly longer for second-year participants compared to first-years (57,15 vs. 38,96 ms). The results show a non-significant interaction between Phonetics Course and Consonant Place ($F [2, 714] = 1,33$, $p = 0,26$), indicating that the differences in duration of aspiration associated to place of articulation do not vary in the two groups (or vice versa). Post-hoc comparisons following the significant Place effect were carried out and revealed significant differences in place of articulation between /p/ and /t/ ($p < 0,01$), and between /p/ and /k/ ($p < 0,01$). Nevertheless, one of the post hoc comparisons also revealed non-existent significant differences between /t/ and /k/ ($p > 0,05$). To sum up, by taking together these results it should be concluded that post-hoc comparisons showed that /p/ differed from /t/ and /k/ which did not differ between them.

There is a universal tendency for bilabials and alveolars to have shorter VOT than velar stops (Liu et al. 2007), as it has been observed throughout the study. Some of the reasons that can account for these VOT differences are the following: laws of aerodynamics, such as the volume of the cavity in relation to the point of constriction, articulatory movement velocity, and the extent of articulatory contact (Cho & Ladefoged 1999).

As Cho & Ladefoged (1999) state 'one of the factors which contribute to VOT differences is the relative size of the supraglottal cavity behind the point of constriction' (209). In other words, velar stops are going to have a longer VOT than bilabial and alveolar ones because their cavity has a smaller volume, and hence this will cause a greater pressure and obstruction, resulting in a greater and longer aspiration. Another reason that accounts for the VOT differences according to place of articulation is the movement of articulators. Articulators, such as the tip of the tongue and the lips, which are used to produce bilabial and alveolar stops, tend to move faster than other articulators, such as the back of the tongue, which is used to produce velar stops. As a result, the faster these articulators move, the shorter the aspiration will be because the pressure and obstruction stored in the cavity will be released in a shorter period of time, resulting in a shorter aspiration. Finally, the extent of articulatory contact is the last reason responsible for VOT differences according to place of articulation. In other words, velar stops have extensive contact with the tongue body and the palate; thus, when velar stops are produced, these articulators are going to come apart more slowly, resulting in the presence of a longer time during the release phase.

Finally, we consider differences in aspiration associated to different vowels /ɪ e æ/. Figure 9 shows the mean VOT values across aspiration and vowel type for voiceless stops for first and second-year participants. The mean VOT value for the lax high front vowel /ɪ/ is 46,03ms (SD=11,04) for the first-year group, and 57,29ms (SD=11,96) for the second-year one. The mean VOT value for the lax mid-high front vowel /e/ is 36,06ms (SD=9,64) for the first-year group, and 57,45ms (SD=11,15) for the second-year one. Finally, the bar graph also shows the mean VOT value for the lax low front vowel /æ/ is 34,38ms (SD=9,78) for first-year students, and 56,67ms (SD=13,88) for second-year students.

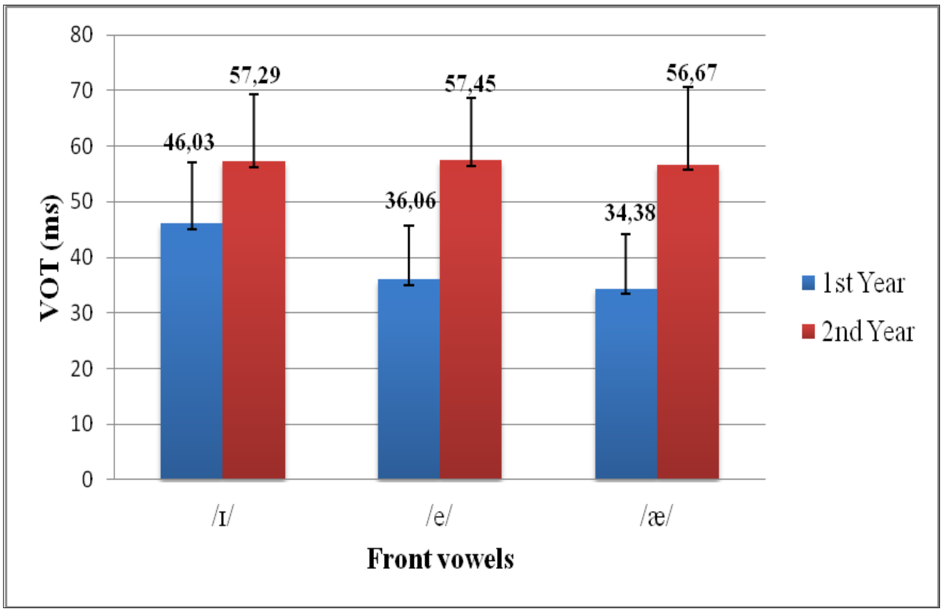

Figure 9. Mean VOT values for voiceless stops by vowel type.

The ANOVA showed a significant Vowel Type effect ($F [2, 714] = 3,64$, $p < 0,05$), indicating that duration of aspiration differs according to the followed vowel (/ɪ/ = 51,66ms, /e/ = 46,76ms, and /æ/ = 45,53ms). It appears that the higher a vowel is, the longer the period of aspiration will be and the lower a vowel is, the shorter the period of aspiration will be. The effect of Phonetics Course was very significant (F [1, 714] =

80,01, p < 0,01), with duration of aspiration being significantly longer with second-year participants compared to first-year ones. Finally, the results show a significant Phonetics Course by Vowel Type interaction (F [2, 714] = 3,26, p = 0,03), indicating that the differences in duration of aspiration for the different vowels vary between the two groups. This is illustrated in the line graph in Figure 10, which shows that First-year students exhibit the predicted behaviour, longer aspiration before a front high vowel than before opener vowels whereas second-year students do not exhibits such differences. This is an unexpected result that we cannot account for at this time.

The line graph in Figure 10 illustrates the interaction between the two factors, such that second years did not show a difference between the three different vowels whereas first years did.

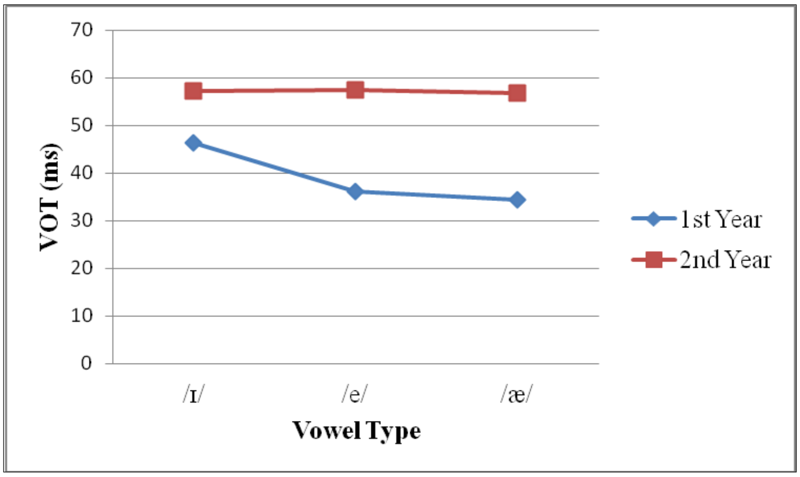

Figure 10. Interaction Effects between Phonetic Course and Vowel Type

Based on previous studies, we expected to find that voiceless stops followed by high vowels would have a greater VOT than those followed by low vowels. This is the tendency shown in our study: the results of the ANOVA show a significant effect of vowel type, with /I/ showing a longer duration of aspiration that lower vowels, and the effect is illustrated in Figure 9. Yavas (2009) expressed that ‘in addition to the place of articulation of the stop, […] the effect of the height of the following vowel' (493) can also account for VOT differences and stated that aspiration in stops tends to be longer whenever they are followed by high vowels and shorter when followed by low vowels. Voiceless stops followed by high vowels have a more obstructed cavity and the resistance offered by the high tongue position for the high front vowel /ɪ/ results in a delay in the onset of vocal fold vibration. On the other hand, voiceless stops followed by non-high vowels have a less obstructed cavity and the resistance offered by the lower tongue position / results in a lesser delay in the onset of vocal fold vibration.

6. Conclusion

The purpose of this study was to examine how English VOT values for word-initial /p, t, k/ were produced by Catalan/Spanish undergraduate learners of English, and whether the effect of an explicit instruction course on Phonetics and Phonology had a positive effect on the production of English aspirated stops or not.

The participants were selected according to a series of necessary requirements, such as their academic year, whether they took the phonetics and phonology course or not, their English proficiency, their linguistic experiences abroad, the language of instruction at Elementary school, their English starting-age, whether they took and still taking extra English classes or not, and whether they have family English-speakers or not.

After having selected the participants from first and second-year by means of their marks and background questionnaires, the selection of the experiment material was done. It consisted of reading out loud a list of 18 minimal pairs which involved bilabial, alveolar and velar stops, and 4 sentences containing voiced and voiceless stops in word-initial position. Afterwards, it was asked to the 16 subjects to read out loud the English minimal pairs in a carrier phrase as well as the English sentences.

Regarding the first research question, our findings have shown that neither Catalan/Spanish undergraduate learners from first-year nor from second-year did produce authentically English VOT values, as it was expected. Nevertheless, the latter group was closer to native speakers than the first-year one. As a result, the data obtained in the acoustic study indicates that there was a significant improvement in the production of VOT between the first-year group and the second-year one. This improvement may be attributed to the Phonetics and Phonology course that the second-year participants took before the experiment.

Furthermore, findings from this study have shown that there is also another difference between reading a particular list of minimal pairs and reading some sentences. As it is predicted in the literature, more attention is paid when minimal pairs are read rather than sentences.

Finally, another finding to highlight is the VOT difference according to the place of articulation of the following consonant and vowel. As literature also predicts, velar stops tend to have a higher degree of aspiration than alveolar and bilabial ones, and the same occurs with vowels. That is to say that the higher the following vowel is, the more aspirated the stop will be.

In conclusion, due to these significant differences in the results obtained by the first-year and second-year group, and the fact that all participants had studied English for an average of 13-14 years, one can confirm the assumption that explicit instruction did have and has a very significant and positive effect on the acquisition of aspiration in word-initial [p^h, t^h, k^h] in English as a second language by Catalan/Spanish speakers.

7. References

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8. Appendices

8.1. Test

1. Read the following phrases FIVE times each:

'Say ______________ twice'

pin

Dan

KET

tin

bat

get

pet

kit

cap

bed

bin

den

gap

pat

din

ten

git

tan

2. Read the following sentences <u>FIVE times each</u>:

a) Kate went to Spain by car.

b) She is still trying to reach this peak.

c) This tale is really touching.

d) Don’t spill the tea on your shirt!

8.2. VOT Tables

8.2.1 First-Year Students

Ex. 1 Participant 1	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Pin	18	2	20	21	7	13,6	8,56
Dan /ð/	-63	-62	-61	-70	-45	-60,2	9,20
KET	34	25	30	22	23	26,8	5,06
Tin	24	26	28	23	17	23,6	4,15
Bat /β/	-95	-94	-40	-72	-92	-78,6	23,55
Get	-64	-58	-45	-49	-88	-60,8	16,93
Pet	26	14	12	15	13	16	5,70
Kit	53	39	53	36	31	42,4	10,08
Cap	25	42	30	27	31	31	6,59
Bed /β/	-84	-120	-83	-63	-75	-85	21,29
Bin /β/	-82	-95	-69	-64	-67	-75,4	12,93
Den /ð/	-90	-117	-78	-80	-65	-86	19,48
Gap /ɣ/	-89	-47	-59	-70	-48	-62,6	17,47
Pat	9	10	9	9	11	9,6	0,89
Din /ð/	-90	-91	-85	-104	-100	-94	7,77
Ten	22	21	14	17	18	18,4	3,20
Git /ɣ/	-74	-101	-58	-78	-80	-78,2	15,40
Tan	23	33	17	18	14	21	7,44

Ex. 2 Participant 1	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Kate	26	22	17	27	26	23,6	4,15
Car	32	31	47	35	28	34,6	7,36
Trying	53	65	42	42	62	52,8	10,80
Peak	21	16	10	14	16	15,4	3,97
Tale	20	24	22	20	21	21,4	1,67
Touching	19	14	20	16	18	17,4	2,40
Tea	21	35	32	34	25	29,4	6,10

Ex. 1 Participant 2	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Pin	17	4	40	48	46	31	19,49
Dan	-141	-85	-70	-86	-83	-93	27,59
KET	32	43	28	24	25	30,4	7,70
Tin	51	37	40	52	39	43,8	7,12
Bat	-135	-93	-123	-103	-111	-113	16,49
Get	-98	-107	-97	-88	-85	-95	8,74
Pet	9	15	24	25	21	18,8	6,72
Kit	78	52	57	58	65	62	10,07
Cap	38	21	23	23	22	25,4	7,09
Bed	-109	-96	-119	-117	-118	-111,8	9,67
Bin	-121	-95	-120	-74	-111	-104,2	19,84
Den	-101	-84	-89	-79	-86	-87,8	8,22
Gap	-102	-79	-71	-103	-71	-85,2	16,13
Pat	45	19	24	14	30	26,4	11,97
Din	-152	-89	-87	-52	-95	-95	36,04
Ten	27	26	38	25	50	33,2	10,75
Git	-116	-104	-90	-103	-92	-101	10,48
Tan	40	27	19	45	32	32,6	10,31

Ex. 2 Participant 2	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Kate	62	31	47	44	53	47,4	11,45
Car	39	56	56	62	72	57	12
Trying	54	57	44	47	60	52,4	6,73
Peak	14	12	23	14	35	19,6	9,60
Tale	56	40	34	37	44	42,2	8,55
Touching	18	10	22	20	15	17	4,69
Tea	55	37	58	55	46	50,2	8,64

Ex. 1 Participant 3	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Pin	44	73	76	106	123	84,4	30,77
Dan /ð/	-54	-75	-80	-94	-112	-83	21,65
KET	57	100	74	104	89	84,8	19,40
Tin	81	87	97	101	115	96,2	13,16
Bat	-94	-89	-65	-44	-103	-79	24,09
Get	-90	-87	-49	-86	-47	-71,8	21,78
Pet	76	42	72	114	69	74,6	25,76
Kit	100	67	149	89	83	97,6	31,10
Cap	107	69	118	83	76	90,6	20,95
Bed /β/	-56	-86	-83	-93	-69	-77,4	14,80
Bin /β/	-159	-79	-91	-72	-68	-93,8	37,47
Den /ð/	-97	-80	-127	-126	-67	-99,4	26,93
Gap	-117	-42	-92	-93	-62	-81,2	29,33
Pat	39	48	79	110	128	80,8	38,42
Din /ð/	-49	-47	-97	-88	-124	-81	32,91
Ten	64	75	117	72	108	87,2	23,65
Git	-110	-112	-83	-94	-96	-99	12,04
Tan	28	75	87	29	86	61	30,04

Ex. 2 Participant 3	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Kate	91	61	99	66	85	80,4	16,30
Car	101	97	109	98	110	103	6,12
Trying	53	108	122	86	100	93,8	26,27
Peak	126	19	30	85	59	63,8	43,27
Tale	32	31	30	31	42	33,2	4,96
Touching	90	83	66	22	70	66,2	26,53
Tea	41	28	19	18	19	25	9,82

Ex. 1 Participant 4	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Pin	19	18	17	13	11	15,6	3,43
Dan	-143	-162	-151	-167	-158	-156,2	9,41
KET	42	48	27	23	44	36,8	11,07
Tin	46	48	45	46	28	42,6	8,23
Bat	-214	-232	-172	-213	-200	-206,2	22,25
Get	-215	-209	-211	-182	-168	-197	20,79
Pet	13	14	11	12	9	11,8	1,92
Kit	57	32	31	53	40	42,6	11,92
Cap	33	31	18	31	27	28	6
Bed	-148	-194	-128	-190	-136	-159,2	30,80
Bin	-152	-110	-181	-198	-204	-169	38,66
Den	-106	-121	-133	-160	-151	-134,2	21,90
Gap	-31	-61	-167	-132	-154	-109	59,80
Pat	9	14	3	20	10	11,2	6,30
Din	-220	-206	-161	-177	-209	-194,6	24,60
Ten	49	40	61	25	45	44	13,15
Git	-58	-61	-110	-108	-156	-98,6	40,54
Tan	39	30	45	28	29	34,2	7,46

Ex. 2 Participant 4	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Kate	37	41	52	41	33	40,8	7,08
Car	53	66	64	43	23	49,8	17,59
Trying	92	90	58	75	41	71,2	21,71
Peak	10	11	9	12	11	10,6	1,14
Tale	23	26	25	26	35	27	4,63
Touching	29	20	16	22	28	23	5,47
Tea	23	24	31	37	29	28,8	5,67

Ex. 1 Participant 5	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Pin	2	12	12	15	8	9,8	5,01
Dan /ð/	-69	-40	-51	-66	-54	-56	11,76
KET	18	32	21	22	22	23	5,29
Tin	42	29	29	27	24	30,2	6,90
Bat /β/	-85	-91	-84	-65	-37	-72,4	22,06
Get	-73	-75	-67	-91	-62	-73,6	10,99
Pet	3	15	9	16	11	10,8	5,21
Kit	47	45	39	46	44	44,2	3,11
Cap	25	24	18	21	17	21	3,53
Bed /β/	-64	-77	-59	-50	-51	-60,2	11,03
Bin /β/	-77	-62	-53	-78	-34	-60,8	18,29
Den /ð/	-44	-45	-39	-34	-46	-41,6	5,02
Gap	-84	-67	-98	-78	-73	-80	11,85
Pat	10	9	10	13	16	11,6	2,88
Din /ð/	-77	-48	-59	-54	-37	-55	14,78
Ten	40	50	21	28	49	37,6	12,81
Git	-57	-73	-80	-84	-89	-76,6	12,42
Tan	14	21	18	21	22	19,2	3,27

Ex. 2 Participant 5	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Kate	35	29	27	35	31	31,4	3,57
Car	37	70	58	61	41	53,4	13,93
Trying	85	84	77	49	80	75	14,88
Peak	7	15	10	14	8	10,8	3,56
Tale	16	21	14	25	26	20,4	5,31
Touching	42	35	36	43	27	36,6	6,42
Tea	49	36	30	40	45	40	7,44

Ex. 1 Participant 6	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Pin	12	14	7	8	9	10	2,91
Dan	-75	-83	-86	-41	-83	-73,6	18,67
KET	12	20	14	15	18	15,8	3,19
Tin	9	9	7	11	11	9,4	1,67
Bat	-107	-105	-96	-79	-97	-96,8	11,05
Get	-95	-88	-93	-43	-52	-74,2	24,71
Pet	7	8	6	9	7	7,4	1,14
Kit	18	21	20	17	41	23,4	9,96
Cap	15	13	23	15	12	15,6	4,33
Bed	-94	-81	-79	-79	-78	-82,2	6,68
Bin	-103	-99	-98	-51	-79	-86	21,65
Den	-93	-73	-107	-61	-67	-80,2	19,21
Gap	-86	-93	-59	-35	-31	-60,8	28,41
Pat	8	8	6	7	8	7,4	0,89
Din	-88	-91	-68	-41	-57	-69	21,05
Ten	7	10	9	10	9	9	1,22
Git /ɣ/	-98	-34	-69	-57	-56	-62,8	23,38
Tan	9	8	7	6	8	7,6	1,14

Ex. 2 Participant 6	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Kate	22	21	15	16	18	18,4	3,04
Car	25	26	41	36	33	32,2	6,76
Trying	57	73	72	47	79	65,6	13,18
Peak	9	9	10	8	10	9,2	0,83
Tale	18	13	11	14	16	14,4	2,70
Touching	12	14	12	10	9	11,4	1,94
Tea	14	12	8	8	7	9,8	3,03

Ex. 1 Participant 7	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Pin	22	23	27	26	20	23,6	2,88
Dan	-77	-78	-71	-92	-75	-78,6	7,95
KET	49	36	41	59	37	44,4	9,63
Tin	94	85	82	102	87	90	8,03
Bat	-81	-93	-76	-112	-101	-92,6	14,63
Get	-55	-54	-63	-90	-103	-73	22,21
Pet	18	17	17	16	11	15,8	2,77
Kit	63	69	103	77	43	71	21,86
Cap	54	35	44	33	37	40,6	8,56
Bed	-80	-83	-74	-131	-91	-91,8	22,75
Bin	-109	-130	-107	-91	-92	-105,8	15,86
Den	-63	-64	-55	-64	-69	-63	5,04
Gap	-65	-54	-45	-80	-43	-57,4	15,33
Pat	21	19	34	12	14	20	8,63
Din	-51	-47	-102	-65	-72	-67,4	21,84
Ten	68	97	67	101	59	78,4	19,17
Git /ɣ/	-145	-98	-102	-98	-78	-104,2	24,66
Tan	66	56	68	70	71	66,2	6,01

Ex. 2 Participant 7	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Kate	44	34	31	35	31	35	5,33
Car	46	58	87	66	50	61,4	16,24
Trying	100	98	68	118	121	101	21,14
Peak	16	14	12	9	9	12	3,08
Tale	40	42	46	51	57	47,2	6,90
Touching	43	33	29	31	51	37,4	9,31
Tea	77	82	78	66	71	74,8	6,30

Ex. 1 Participant 8	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Pin	36	67	40	66	77	57,2	18,10
Dan /ð/	-101	-52	-85	-38	-87	-72,6	26,40
KET	54	60	61	64	61	60	3,67
Tin	46	70	82	89	94	76,2	19,13
Bat /β/	-89	-81	-103	-109	-111	-98,6	13,06
Get	-84	-82	-77	-70	-87	-80	6,67
Pet	15	21	35	42	30	28,6	10,78
Kit	75	67	77	85	68	74,4	7,33
Cap	30	47	70	67	72	57,2	18,18
Bed /β/	-93	-84	-114	-97	-108	-99,2	11,94
Bin /β/	-166	-90	-120	-88	-148	-122,4	34,62
Den	-59	-74	-86	-71	-105	-79	17,42
Gap	-83	-106	-70	-97	-101	-91,4	14,70
Pat	20	32	49	45	50	39,2	12,91
Din	-74	-110	-83	-74	-105	-89,2	17,19
Ten	26	43	63	84	44	52	22,16
Git	-36	-43	-90	-84	-112	-73	32,40
Tan	67	59	69	86	59	68	11,04

Ex. 2 Participant 8	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Kate	40	52	67	44	62	53	11,48
Car	83	57	73	35	30	55,6	23,10
Trying	73	79	78	86	92	81,6	7,43
Peak	16	30	18	13	17	18,8	6,53
Tale	39	29	24	25	27	28,8	6,01
Touching	44	30	21	24	23	28,4	9,34
Tea	84	83	71	64	74	75,2	8,40

8.2.1 Second-Year Students

Ex. 1 Participant 9	1st	2nd	3rd	4th	5th	Average	Standard Deviation
Pin	32	20	17	18	11	19,6	7,700649323
Dan /ð/	-91	11	-87	-92	-107	-73,2	47,67808721
KET	57	65	64	77	83	69,2	10,54514106
Tin	66	55	53	51	48	54,6	6,877499546
Bat	-137	14	-121	-134	-156	-106,8	68,67823527
Get	20	29	29	21	23	24,4	4,335896678
Pet	21	13	11	14	23	16,4	5,272570531
Kit	87	67	65	57	78	70,8	11,75584961
Cap	55	56	59	64	34	53,6	11,50217371
Bed	-125	12	-92	-110	-128	-88,6	58,02413291
Bin	8	-118	-103	-129	-132	-94,8	58,58071355
Den	-115	13	/ð/ -81	-99	-106	-76,75	62,41233852
Gap	29	25	24	24	27	25,8	2,167948339
Pat	37	13	11	13	7	16,2	11,88276062
Din	18	-83	-79	-98	-92	-66,8	47,98645642
Ten	51	45	50	44	39	45,8	4,868264578
Git	29	32	30	29	29	29,8	1,303840481
Tan	46	29	27	40	24	33,2	9,364827815

Ex. 2 Participant 9	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Kate	42	47	38	32	35	38,8	5,89
Car	54	49	41	44	42	46	5,43
Trying	74	64	84	79	67	73,6	8,26
Peak	20	15	19	17	16	17,4	2,07
Tale	13	17	34	30	11	21	10,36
Touching	49	48	53	47	43	48	3,60
Tea	92	71	73	68	80	76,8	9,57

Ex. 1 Participant 10	1st	2nd	3rd	4th	5th	Average	Standard Deviation
Pin	102	61	133	98	42	87,2	35,92
Dan	16	10	9	10	10	11	2,82
KET	92	114	94	103	93	99,2	9,36
Tin	62	76	80	89	90	79,4	11,39
Bat	10	10	9	11	11	10,2	0,83
Get	18	17	16	17	17	17	0,70
Pet	103	76	93	82	67	84,2	14,13
Kit	87	80	85	92	80	84,8	5,06
Cap	82	98	88	79	105	90,4	10,92
Bed	13	12	11	12	13	12,2	0,83
Bin	11	13	11	11	10	11,2	1,09
Den	14	15	16	14	15	14,8	0,83
Gap	19	18	19	19	17	18,4	0,89
Pat	75	44	42	41	40	48,4	14,94
Din	16	15	15	16	16	15,6	0,54
Ten	102	118	89	115	88	102,4	14,04
Git	23	20	21	22	23	21,8	1,30
Tan	84	122	72	102	94	94,8	18,89

Ex. 2 Participant 10	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Kate	107	90	87	73	66	84,6	15,94
Car	89	88	85	61	84	81,4	11,58
Trying	86	85	90	110	100	94,2	10,63
Peak	92	29	14	30	16	36,2	32,03
Tale	15	18	47	27	51	31,6	16,54
Touching	80	68	62	63	57	66	8,74
Tea	88	74	55	66	83	73,2	13,21

Ex. 1 Participant 11	1st	2nd	3rd	4th	5th	Average	Standard Deviation
Pin	34	60	47	21	77	47,8	21,85
Dan /ð/	-125	-172	-150	-175	-161	-156,6	20,23
KET	99	87	63	88	93	86	13,71
Tin	70	74	75	102	92	82,6	13,74
Bat	-115	21	-165	-147	-151	-111,4	76,24
Get	35	36	32	35	33	34,2	1,64
Pet	24	41	65	45	57	46,4	15,74
Kit	64	119	103	100	108	98,8	20,75
Cap	70	79	89	86	113	87,4	16,07
Bed	-106	-107	-81	-191	-200	-137	54,50
Bin	-136	-158	-158	-150	-181	-156,6	16,33
Den	20	16	26	21	19	20,4	3,64
Gap	36	35	36	36	34	35,4	0,89
Pat	39	67	86	88	86	73,2	20,94
Din /ð/	37	12	-143	20	-72	-29,2	76,29
Ten	87	64	77	71	76	75	8,45
Git	28	30	-134	30	28	-3,6	72,90
Tan	73	87	94	78	64	79,2	11,73

Ex. 2 Participant 11	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Kate	73	47	51	60	45	55,2	11,49
Car	85	89	68	74	78	78,8	8,40
Trying	90	89	92	87	71	85,8	8,46
Peak	22	20	18	15	17	18,4	2,70
Tale	61	54	40	56	36	49,4	10,80
Touching	44	36	43	31	32	37,2	6,05
Tea	63	78	79	47	76	68,6	13,68

Ex. 1 Participant 12	1st	2nd	3rd	4th	5th	Average	Standard Deviation
Pin	21	12	22	20	23	19,6	4,39
Dan /ð/	-94	-114	-92	-99	-132	-106,2	16,79
KET	73	93	67	82	76	78,2	9,88
Tin	31	63	55	35	58	48,4	14,41
Bat	-144	-110	-127	-117	-125	-124,6	12,77
Get	28	-123	-112	-99	-121	-85,4	64,09
Pet	26	22	35	28	10	24,2	9,23
Kit	69	67	59	53	60	61,6	6,46
Cap	64	46	84	58	49	60,2	15,10
Bed	-128	-116	-117	-131	-107	-119,8	9,73
Bin	-132	-135	-130	-113	-134	-128,8	9,03
Den	-96	-114	-123	-105	-102	-108	10,60
Gap	22	31	23	24	30	26	4,18
Pat	48	67	45	37	9	41,2	21,09
Din	-120	-93	-126	-140	-129	-121,6	17,55
Ten	32	31	64	38	69	46,8	18,26
Git	20	21	29	27	28	25	4,18
Tan	33	59	51	52	34	45,8	11,64

Ex. 2 Participant 12	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Kate	45	46	27	47	65	46	13,45
Car	85	52	54	54	82	65,4	16,57
Trying	67	64	47	44	77	59,8	13,95
Peak	27	36	13	12	72	32	24,50
Tale	19	18	28	9	64	27,6	21,43
Touching	18	24	16	34	26	23,6	7,12
Tea	24	34	62	27	17	32,8	17,42

Ex. 1 Participant 13	1st	2nd	3rd	4th	5th	Average	Standard Deviation
Pin	16	14	20	15	13	15,6	2,70
Dan /ð/	-103	-91	-73	-87	-79	-86,6	11,52
KET	31	27	45	35	41	35,8	7,29
Tin	32	28	44	41	45	38	7,58
Bat /β/	-118	-93	-99	-97	-90	-99,4	10,96
Get	30	23	23	16	23	23	4,94
Pet	21	13	18	24	23	19,8	4,43
Kit	44	64	35	48	30	44,2	13,16
Cap	54	51	44	33	52	46,8	8,58
Bed	-119	-98	-106	-103	-107	-106,6	7,76
Bin	-103	-91	-94	-88	33	-68,6	57,07
Den /ð/	-105	-95	-106	-100	-107	-102,6	5,02
Gap	36	26	17	23	16	23,6	8,08
Pat	78	11	36	58	18	40,2	27,87
Din /ð/	-120	-124	-102	-101	-89	-107,2	14,51
Ten	31	40	51	33	51	41,2	9,54
Git /ɣ/	23	28	24	20	16	22,2	4,49
Tan	27	22	89	56	43	47,4	26,85

Ex. 2 Participant 13	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Kate	60	42	46	19	45	42,4	14,80
Car	56	54	59	64	67	60	5,43
Trying	51	55	51	34	46	47,4	8,14
Peak	11	12	10	12	9	10,8	1,30
Tale	34	21	32	35	40	32,4	7,02
Touching	12	11	14	13	14	12,8	1,30
Tea	32	30	26	25	37	30	4,84

Ex. 1 Participant 14	1st	2nd	3rd	4th	5th	Average	Standard Deviation
Pin	25	16	20	37	23	24,2	7,91
Dan	16	21	18	29	24	21,6	5,12
KET	46	31	46	33	32	37,6	7,70
Tin	48	40	47	44	58	47,4	6,69
Bat	15	14	15	14	14	14,4	0,54
Get	27	25	25	31	30	27,6	2,79
Pet	12	30	8	12	13	15	8,60
Kit	37	48	57	68	54	52,8	11,43
Cap	52	22	37	40	33	36,8	10,89
Bed	12	-94	10	13	13	-9,2	47,42
Bin	13	9	14	17	15	13,6	2,96
Den	20	16	21	21	22	20	2,34
Gap	-75	29	33	17	21	5	45,16
Pat	26	18	17	22	24	21,4	3,84
Din	21	18	18	35	20	22,4	7,16
Ten	30	29	26	60	49	38,8	14,92
Git	30	34	32	47	58	40,2	11,96
Tan	46	41	40	46	36	41,8	4,26

Ex. 2 Participant 14	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Kate	43	45	35	34	35	38,4	5,17
Car	48	53	43	48	80	54,4	14,74
Trying	71	43	37	56	60	53,4	13,57
Peak	18	20	17	26	13	18,8	4,76
Tale	19	16	22	13	20	18	3,53
Touching	34	30	37	36	33	34	2,73
Tea	60	75	49	56	49	57,8	10,70

Ex. 1 Participant 15	1st	2nd	3rd	4th	5th	Average	Standard Deviation
Pin	56	94	58	60	61	65,8	15,88
Dan	51	45	47	40	51	46,8	4,60
KET	88	84	69	74	91	81,2	9,36
Tin	43	68	61	48	76	59,2	13,70
Bat	-82	-184	-101	-191	-180	-147,6	51,80
Get	20	15	11	13	16	15	3,39
Pet	87	104	69	45	86	78,2	22,30
Kit	69	84	68	70	60	70,2	8,67
Cap	75	95	46	55	67	67,6	18,91
Bed	-101	-172	-106	-114	-102	-119	30,06
Bin	-125	-11	-116	-133	-105	-98	49,73
Den	38	32	40	30	31	34,2	4,49
Gap	20	16	11	13	15	15	3,39
Pat	56	98	80	63	45	68,4	20,86
Din	29	34	35	31	33	32,4	2,40
Ten	72	70	74	77	82	75	4,69
Git	21	19	14	16	17	17,4	2,70
Tan	72	80	81	68	61	72,4	8,38

Ex. 2 Participant 15	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Kate	51	63	65	57	50	57,2	6,79
Car	104	66	96	98	79	88,6	15,67
Trying	11	109	105	109	103	87,4	42,78
Peak	73	72	51	122	27	69	35,07
Tale	46	35	41	16	14	30,4	14,60
Touching	65	70	77	51	48	62,2	12,39
Tea	123	96	112	87	81	99,8	17,45

Ex. 1 Participant 16	1st	2nd	3rd	4th	5th	Average	Standard Deviation
Pin	67	25	36	37	59	44,8	17,49
Dan	-134	20	24	-104	27	-33,4	78,89
KET	70	51	69	80	50	64	13,05
Tin	85	74	85	91	73	81,6	7,79
Bat	-136	-106	-120	9	-119	-94,4	58,77
Get	-77	15	-104	19	17	-26	59,66
Pet	55	43	42	38	57	47	8,45
Kit	76	61	64	89	91	76,2	13,80
Cap	89	70	81	78	69	77,4	8,26
Bed	-114	-129	-120	-131	-128	-124,4	7,16
Bin	-127	-142	-124	-134	-119	-129,2	8,98
Den	20	21	17	-135	9	-13,6	68,02
Gap	18	22	21	16	17	18,8	2,58
Pat	54	45	32	51	27	41,8	11,81
Din	28	-98	15	12	28	-3	53,60
Ten	70	66	76	77	69	71,6	4,72
Git	21	21	21	24	23	22	1,41
Tan	81	67	71	60	95	74,8	13,60

Ex. 2 Participant 16	1st ms	2nd ms	3rd ms	4th ms	5th ms	Average	Standard Deviation
Kate	28	51	46	43	76	48,8	17,45
Car	77	69	77	113	85	84,2	17,06
Trying	96	79	80	91	88	86,8	7,25
Peak	50	33	39	76	18	43,2	21,67
Tale	92	23	29	81	29	50,8	32,91
Touching	57	32	47	48	33	43,4	10,69
Tea	65	64	48	82	49	61,6	13,93

8.3. Informed Consent Form

UAB
Universitat Autònoma de Barcelona

Informed Consent Form

Purpose of this Research Study

You are invited to participate in a research study investigating the pronunciation of English aspirated plosives by Spanish/Catalan speakers. This study is being conducted as a final project (*Treball de Fi de Grau*) for a bachelor's degree in English Studies at the Autonomous University of Barcelona.

Procedures

Participation involves being recorded while reading some lexical items out loud.

Confidentially

The confidentially of the participant will remain secure. The names of the participants will also be protected (pseudonyms will be used).

Contacts

Any questions or problems you may have can be answered by:

Principal Researcher: Ariadna Casas Solà (email address: ariadna.casas@gmail.com)

TFD Supervisor: Maria-Josep Solé (email address: mariajosep.sole@uab.cat)

Authorisation

I have read and understood the consent form, and I volunteer to participate in this research study.

Participant's Name:______________________________

Participant's Signature:______________________________

Date: ______________________________

Principal Researcher's Signature : ______________________________