Representations and transfer processes

in L2 speech production:

Evidence from Catalan learners of English

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DECLARATION

I hereby declare that this thesis is all my own work unless otherwise acknowledged in the text, and that it has not been submitted for any other degree or professional qualification.

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ABSTRACT

The present thesis examines L1 transfer in L2 production. This thesis investigates the possible role in L2 speech production of 1) various types of sound representations (underlying and surface segments), their mappings to L2 sound categories and their phonetic realisation 2) speech perception and 3) the effect of the morphological composition of L2 words.

The advanced Catalan learners of English, who served as subjects in the study, displayed more accuracy in their production of target English /d/ and /ð/ in contexts where they surface in Catalan than in the production of /d/ in intervocalic position and /ð/ in initial position. Their perceptual identification of target /d/ and /ð/ in both initial and intervocalic position could not predict their production. However, these findings could be accounted for by positing the transfer of L1 underlying segments as well as an L1 underlying to surface realisation mechanism onto the L2 system. The replication of a study by Eckman and Iverson (1997) on the role played by morphology in L2 speech production shows that L2 speakers' production of /d/ does not depend on whether the lexical items are derived or non-derived.

Overall, the findings in the different experiments display the possibility of predicting transfer in L2 production based on L1 surface realisation patterns. Results are discussed in terms of traditional Generative Phonology, as well as Optimality and Exemplar Theories.

ACKNOWLEDGEMENTS

CONTENTS

CHAPTER 1

Introduction and Literature Review

1.1. Introduction

When people learn a new language, there are tasks they have to face which involve a strong effort. With work and in due time, language learners manage to master different areas in the new language. An especially difficult task is to overcome the so-called 'foreign accent'. Of course, some people are naturally gifted when it comes to accent imitation and sound learning but, in general terms, the majority of L2 learners do not sound 'native-like' when they first attempt to speak a foreign language. Not only that, but also many of them keep sounding 'non-native' even when reaching high levels of proficiency in other linguistic areas of L2, as already pointed out by Gerard (1967, credited by Scovel (1969)). An important source of foreign accent comes from the prosodic differences between learners' L1 and L2: different intonation contours, different stress patterns, and so on. Apart from that, using L1's sounds when trying to pronounce the L2 also results in a foreign accent. But then, we could more specifically ask whether all L2 sounds are problematic. Or is it only some of them? If so, which ones? And are these sounds always problematic or only under certain conditions? Is it a matter of position of these sounds in the word? Or does it depend on the morphological configuration of words? All these questions are addressed in the thesis.

In the present thesis I focus on the description of L2 production and I account for how L1 influences L2 pronunciation in learners with an advanced proficiency level in L2. I specifically focus on production transfer at the segmental level because this topic allows us to address the nature of the representational units that undergo transfer at different levels.

It has been widely observed that a difference in L1's segmental inventory as compared to L2 is often a predictor of foreign accent. For example, French speakers of English tend to drop the /h/ in words like 'house' because /h/ does not exist in their L1. According to one view, foreign accent in production could be due to perceptual problems in accurately identifying L2 segments. Another view suggests that problems in L2 production do not always depend on perceptual difficulties. I suggest that transfer processes in the speech production process could account for the behaviour in L2 production, which shows a different pattern from L2 perception. In this thesis I intend to determine which L1 units or representations transfer to the L2 system when production cannot be explained in terms of the speakers' perception of the target L2 segments.

1.2. L2 production, L2 perception and the relationship between them

A substantial amount of research has shown that the transfer of phonological or phonetic characteristics at the segmental and suprasegmental level from L1 to L2 plays an important role in foreign accent (Brière, 1966, 1968; Broselow, 1984; Cebrián, 2000; Flege, 1987, 1991, 1992, 1993, 1995, 1997a, 1997b; Flege et al., 1999; Hecht & Mulford, 1982; Lado, 1957; Zampini, 1994; Stockwell & Bowen, 1983; Zsiga, 2003) but see Altenberg & Vago (1983), Major & Faudree (1996), and Nemser (1971) for examples of foreign accent which cannot be attributed to transfer.) This thesis specifically focuses on the phenomenon of segmental transfer. When dealing with transfer in production, the idea that perception of L2 sounds plays an important role comes to mind because of the undeniable link between both skills. However, it is still unclear which role each one of them plays in the building of a L2 phonological system. Many studies have been devoted to the

study of how L1 segments affect the perception of L2 segments (Best, 1994, 1995, 1999; Best et al., 1988; Best & Strange, 1992; Brown, 1998, 2000; Guion et al., 2000; Kohler, 1981; Rochet, 1995; Bohn, 1995; Werker & Tees, 1984; among others). L1 appears to filter or warp the perception of L2 phones. Therefore, some have claimed that mispronunciation of L2 segments could only reflect a problem in perception, if we assume that perception conditions production. A considerable body of research has examined the relationship between the production and perception of L2 segments (Borden et al., 1983; Brière, 1968; Caramazza et al., 1973; Cortés, 1999a, 1999b, 2000; Flege, 1991, 1992, 1993, 1995, 1997a, 1997b; Flege et al., 1997; Flege et al., 1999; Goto, 1971; Rochet, 1995; Sheldon & Strange, 1982). However, the relationship between these two linguistic skills in L2 learners is still controversial because it is unclear which skill is first mastered by the L2 learners and whether one conditions the other.

The relationship between L2 speech perception and production has been attempted to be accounted for in Flege's Speech Learning Model. The SLM (1987, 1995) assumes that the perception of L2 segments determines whether the L2 learners associate the L2 segment with an existing category in L1 (i.e. a 'similar' phone) or create a category for the L2 phone (i.e. a 'new' phone). According to his model, L2 learners can construct phonetic categories for an L2 sound if they can detect a phonetic difference from the closest L1 phone. That is, L2 speakers will create categories for phones that are perceived to be 'new', following Flege's terminology. However, L2 phones which are perceived as 'similar' will present problems because Equivalence Classification will operate. Equivalence Classification causes 'similar' phones to be judged as realisations of L1 categories and, therefore, no new categories will be created for the L2 phones. The L2 phone will be assimilated to the L1 category and will be pronounced non-authentically. For example, Spanish speakers of English do not have the English /i/ and /ɪ/ distinction in their L1. Spanish only has /i/. Since the two English

phonemes are phonetically within the realm of Spanish /i/, Spanish speakers will not detect a phonetic difference between the English /i/ and /ɪ/. Therefore, their production of target English /i/ and /ɪ/ will show the merging of both English phones onto one single category /i/. They will not be able to create a separate category for English /ɪ/ due to Equivalence Classification.

Since the relationship between production and perception is crucial for his model, Flege himself (1999) reviewed different studies on the relation between L2 production and perception. He observed that correlations are found in all studies even though they are not strong. Such findings raise the question of whether there are aspects specific to production itself that transfer from L1 to L2.

The asymmetry that seems to affect production and perception was already pointed out by Neufeld (1988). In his study, he found that advanced learners of an L2 were far better in perceiving L2 segments than in producing them in the native fashion. Cortés (1999a, 1999b) confirmed Neufeld's finding that perception is a condition for good production of consonants. Rochet's study (1995) also shows that perception conditions production. Inaccurate perception of L2 phones seems to play "an important role in the phenomenon of foreign accent" (p. 403), as well as other studies have pointed out (Flege, 1993; Flege et al., 1999).

However, in a subsequent pilot study, Cortés (2000) found that the production accuracy in the Catalan subjects who could identify and those who could not identify English /ð/ and /v/ accurately was very similar. The subjects who did not perceive the fricatives as such produced them far better than expected. In the same vein, some subjects who could perceive the fricatives as fricatives produced them worse than expected. Similarly, Flege and some colleagues (Flege et al., 1997) found that, even though some of the regressions they ran could account for accuracy in production of vowels in

terms of accuracy in vowel perception, "a substantial amount of variance in the production data remained unaccounted for. Of course, we cannot rule out the possibility that changes in production occur first, or that they occur in the absence of corresponding changes in perception." (p. 467)

Further evidence for production to be better than perception was provided by Brière (1968). He had already pointed out that "production of sounds in isolation always preceded perception of sounds" (p. 73), in his study. However, even though the production of sounds is better than their perception, we should notice that his data shows production of sounds in isolation against perception of sounds within words. The sounds surrounding the target segments and their coarticulatory effects could have made a difference in the perceived production. Some other studies have also shown that the production of /r/ and /l/ by Japanese learners of English was better than their perception (Goto, 1971; Sheldon & Strange, 1982).

It is still unclear whether acceptable segmental production is determined by accurate identification of segments in L2 or vice versa. Given the disparity in results in the different studies, we want to test whether perception can explain L2 speech production. In addition, in situations in which production and perception of given segments do not match, we might be able to explain how transfer from L1 production to L2 production exactly works. This thesis aims to determine the representations and processes involved in speech production that transfer from L1 to L2.

1.3. Speech production in Generative Phonology

Let us first consider what happens in L1 speech production. When we speak, we retrieve words from the lexicon that convey semantic information. Words are traditionally thought to be composed of representational units.

The representations that convey lexical contrasts have traditionally been called 'phonemes', and they surface in different acoustic variable realisations. Phonemes are mapped onto a phonetic realisation at the surface level[1]. In the Generative Phonology approach, this L1 phoneme-to-allophone mapping is realised by means of rules (if following the SPE model – Chomsy & Halle, 1968). We will use the term surface segment when our model examples deal with realisations of underlying segments which happen to be in complementary distribution (i.e. context-conditioned surface segments.)

This view of the speech production process assumes that the different representations are operating at different levels: underlying forms are underlying representations whereas surface forms are surface context-conditioned realisations. A schematic representation suggesting correspondences between abstract underlying representations and surface representations follows. In this thesis, the terms underlying form and surface form are used in order to be able to claim that underlying form is transferred without transferring all its acoustic variable realisations. If we used the term 'phoneme', such a key theoretical assumption in the present thesis would be ruled out.

Contrastive (underlying) representation	/underlying segment/
Underlying-to-surface mapping	↓
Acoustic variable realisations	[surface segment]
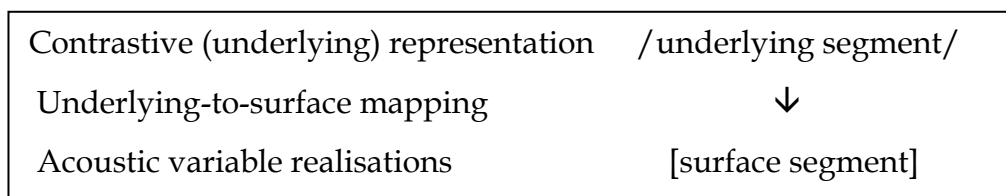
Fig. 1.1. Correspondence between underlying and surface segments

This correspondence from the underlying to the surface form can be either a one-to-one correspondence (e.g., as in phonemes that only have one acoustic realisation) or a one-to-many correspondence (e.g., as in phonemes that have different context-conditioned realisations, what has traditionally been called

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[1] Phonetic or surface realisation refers to the acoustic signal, not to a mediating level between phonological representation and the acoustic output (SPE).

allophonic variation). The topic of this thesis is precisely the study of a one-to-many correspondence in L1 (i.e. Catalan and Spanish, which have [d̪] and [ð̪] as realisations of /d̪/) which is different from a one-to-one correspondence in L2 (i.e. English, which has /d/ and /ð/ as different phonemes). The thesis aims at describing and explaining the transfer processes that bilingual speakers of Catalan use in producing the English consonants /d/ and /ð/.

In order set the scene, let us have a look at the consonant systems of these bilingual speakers in order to be able to compare the inventories they hold in their L1s with that of the target language, namely English.

1.4. Description of Catalan, Spanish and English consonants

Catalan is spoken in Catalonia. The dialect spoken in the province of Barcelona, part of Tarragona and part of Girona is known as Central Catalan. The phonological consonant inventory of Central Catalan and of most Catalan dialects is the following (following Veny, 1998)[2]:

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[2] The /d̪/ and /t̪/ stops are dental, not alveolar. Majorcan Catalan includes a voiced labiodental fricative in its phonological inventory, but that is not relevant for the current study.

p	t̪			k
b	d̪			g
			tʃ	
			dʒ	
f		s	ʃ	
		z	ʒ	
m		n	ɲ	
		ɾ		
		r		
		l	ʎ	

Fig. 1.2. Consonant system of Catalan

All Catalan speakers nowadays are bilingual in Spanish. Therefore, the subjects in this study do not only have the Catalan consonants but also the Spanish ones as a reference when they learn new languages. The Spanish inventory in peninsular Spanish has been described as having the following consonants (adapted from Llisterri, 2006):

p	t̪		k
b	d̪		g
		t ʃ	
f	θ	s	x
		z	
m		n	ɲ
		ɾ	
		r	
		l	ʎ

Fig. 1.3. Consonant system of Spanish

As the contrast of interest in their target language is that of /d/ and /ð/ in English, the crucial phonological process which affects our study is that all voiced stops undergo spirantisation (i.e. they become homorganic fricatives or approximants) in intervocalic and postcontinuant position in all Catalan dialects (Recasens, 1991). Therefore, in absolute initial position, voiced dental stops occur but in intervocalic position they surface as fricatives (Mascaró, 1984) or approximants (Recasens, 1991; Palmada, 1997; Bonet & Lloret, 1998). The debate between phonologists and phoneticians as to the manner of articulation of the Catalan spirantised allophones is not the main focus of our study. Incidentally, the same debate exists about the actual manner of articulation of spirantised stops in Spanish (for fricatives: Mascaró, 1984;

Harris, 1969; for approximants: Ladefoged, 1993; Martínez Celdrán, 1998; Romero, 1995).

We will assume that a weakening process takes place in this environment. We will use the labels 'stop' vs. 'approximant' in the description of Catalan, in which 'approximant' only indicates a non-stop manner of articulation. Some examples are provided below in order to clarify the distribution of the sounds that were examined in this project.

In all Catalan dialects, the word *dir* 'to say' starts with the voiced dental stop /d̪/, whereas, in the word *cada* 'each', the <d> is pronounced as the approximant allophone [ð̞̊] because it is in intervocalic position. The particularity about spirantisation in Catalan, with respect to spirantisation in Basque, Spanish and Portuguese, is that it only occurs across syllabic boundaries (Palmada, 1997) in voiced stops. That is, we find spirantisation in a word like *cada* 'each' [ˈka.ð̞̊ə] because the stop is after the syllabic boundary and it becomes an approximant due to the effect of the vowel preceding the boundary. However, spirantisation does not take place in the bilabial stop although it is in postcontinuant position in a word like *abdomen* 'abdomen' [əb.ˈdɔ.mən] in Catalan because that stop shares the syllable domain with its preceding vowel. Conversely, in Spanish we find that its cognate *abdomen* 'abdomen' [aβ.ˈð̞̊o.men] shows spirantisation of the bilabial stop because of the preceding vowel even when the vowel and the stop share the same syllable.

The English consonant system is the following (adapted from Ladefoged, 1993):

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p      t                    k

b      d                    g

                      tʃ

                      dʒ

f      θ         s      ʃ

v      ð         z      ʒ

   m             n      ŋ

                 ɹ

                 l
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Fig. 1.4. Consonant system of English

With regard to English production, in an acoustic and articulatory study, Lavoie (2001) reported that English speakers do neither always produce target stops as stops nor target fricatives as fricatives. According to her analysis, /d/ was produced as a stop in 72% of the cases and as an approximant in 24% of the cases. In her study the initial stops were not in an absolute initial position, which is what we consider in this study. In Lavoie's study, the non-absolute initial position of the stops might explain the high number of approximant realisations of target stops, even though stops are not supposed to be influenced by the context in which they occur in English. There might be an assimilation of the [+ continuant] feature from the glide at the end of *say* because she elicited the target words in the carrier sentence "*Please say X for me*" (ibid: p.64). Lavoie does not mention whether the approximant realisations are actually perceived as such when heard by a native English speaker.

As for the production of target fricatives, Lavoie's English speakers produced target /ð/ as a stop in 24% of the cases, as a fricative in 9%, as an approximant in 59%, and as a glide in an 8%. The present study is not acoustic in nature but will focus on whether /d/ and /ð/ are produced as stops or as weaker consonants by bilingual speakers of Catalan and Spanish, and whether native English transcribers perceive Catalan-Spanish bilinguals' English productions as stops or non-stops.

When observing the Catalan and Spanish system alongside the English one, the most important difference in the coronal obstruents is that the English voiced coronal stop is alveolar (i.e. /d/) whereas the Spanish and Catalan voiced coronal stops are dental (i.e. /d̪/). As for fricatives, English has both a voiced and a voiceless dental fricative (i.e. /ð/ and /θ/). Spanish has a voiceless dental fricative (i.e. /θ/) and Catalan none, as phonemes. However, spirantisation in Spanish and Catalan makes voiced dental stops surface as dental approximants (i.e. [ð̞]) in postcontinuant position. Although the English and the Catalan and Spanish consonants differ slightly in the place of articulation for the stops and in manner of articulation (i.e. dental approximant dental in Spanish and Catalan as compared to the dental fricative in English), we assume that Catalan learners of English use [d̪] and [ð̞] as reference for their production of English /d/ and /ð/. We assume this because they are the most similar segments in their L1s to the L2 target segments. The most salient difference between the target English segments is the manner of articulation (i.e. stop vs. fricative). As the Catalan and Spanish surface forms differ in manner of articulation between them too (i.e. stop vs. approximant), we could say that the English contrast will be kept by bilingual Catalan-Spanish speakers if they produce their L1 surface segments. The Catalan and Spanish segments are equivalent to the English

ones in that they have a coronal stop against a coronal non-stop (i.e. an approximant in Catalan and Spanish or a fricative in English).

In this thesis, the focus is on manner of articulation rather than place of articulation given that a difference in place of articulation does not convey a contrast in meaning in the target language. Therefore, the English production by bilingual speakers of Catalan and Spanish will be considered to be target-like when the manner of articulation is the right one. I assume that English listeners will perceive dental productions of stops as their alveolar stops in terms of contrast. The main comparison is whether the production is that of a stop or that of a non-stop, due to the fact that English has dental fricatives whereas Spanish and Catalan have dental surface approximants that could work as their equivalents.

1.5. Speech production in Generative Phonology and other more recent approaches

Let us take an example from Catalan and apply it to the view of speech production introduced in 1.3. Catalan has a voiced dental stop /d̪/. This underlying segment maps onto two different realisations, which are in complementary distribution. The voiced dental stop /d̪/ [3] is realised as a voiced dental approximant [ð̪] when the segment occurs in postcontinuant (other than /l/) position (Palmada, 1997; Bonet & Lloret, 1998). Some examples of spirantised /d̪/ after continuants are the pronunciation of /d̪/ in the word *cada* [ˈkað̪ə] 'each', *desdeny* [d̪əzˈð̪ɛɲ] 'disdain' and *perdre* [ˈpɛɾð̪ɾə] 'to lose', but there is no spirantisation when the voiced dental

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[3] We describe /d̪/ to be the underlying form because its [d̪] realisation has the least restricted distribution.

stop follows a lateral, as in *balda* [ˈbald̪ə] 'doorknocker'. The underlying /d̪/ is pronounced as a voiced dental stop elsewhere (e.g. *dia* [ˈd̪ia] 'day'). Catalan [d̪] and [ð̪] are in complementary distribution (i.e. they do not contrast and where one occurs, the other does not). A schematic representation of the underlying and surface structure of Catalan /d̪/ is provided in Fig. 1.5.

Contrastive (underlying) representation	/d̪/	
Underlying-to-surface mapping	↙	↘
Acoustic variable realisations	[ð̪]	[d̪]
Context	postcontinuant	elsewhere
	position (except after /l/)	

Fig. 1.5. Schematic derivation of Catalan and Spanish surface [ð̪] and [d̪] from underlying /d̪/.

These two levels of representation have minimal units which have traditionally been called phoneme (in the underlying level) and the acoustic variable realisation (in the surface one). The notion of phoneme dates back from the first days of modern phonology. Scholars such as Saussure, Trubetzkoy, Jakobson, Bloomfied and Sapir have all assumed the existence of a representational unit called 'phoneme'. However, the status of phoneme in phonological theory is not without controversy although its abstract status and existence has been assumed in traditional approaches to phonology. A more recent phonological theory like Optimality Theory (see McCarthy, 2002 for a broad account of the main tenets and issues in this theory), which originated from Generative Phonology, also includes phonemes in its

description of the phonological process. However, phonemes are not assumed to form part of an inventory, as in traditional Generative Phonology. There are no pre-specified inventories of phonemes for languages in Optimality Theory. They are the result of the ranking of constraints in the grammar of the language. Another recent approach to phonology is that of Exemplar Theory. In the standard version of this theory, Goldinger (1998) did not postulate sublexical representations. That is, words are the exemplars that we store in our memory. However, a further development of the theory known as the Hybrid version of Exemplar Theory (Pierrehumbert, 2001, 2003a, 2003b) does put forward sublexical representations. Pierrehumbert claims that units at the segmental level exist although the definition of the different representational units in her model lacks clarity.

What traditional Generative phonology and OT have in common is the assumption that there are underlying segments and surface segments. In the model adopted in this thesis, I assume the existence of both levels of representation as a working hypothesis. The results of our experiment could be explained by the model or otherwise provide evidence against the need to have these two representational levels. We will not talk about phonemes but underlying segments and these underlying segments will have different surface realisations or forms, in order to avoid all the different connotations that the terms phoneme and allophone carry due to their long existence.

If we assume the existence of underlying segments in the inventories of speakers of a given language, then we could test in a straightforward way whether the L1 underlying and their mapping onto surface forms transfer onto the L2 systems of L2 learners. As the assumption of inventories is used in the traditional Generative Phonology, this is the framework within which we devise our models for the present thesis.

1.6.   Tools used in the elaboration of our hypotheses

In this thesis, I want to test the adequacy of different models that predict the product of L2 phonology depending on the transfer of the L1 underlying segments and the rules that map L1 underlying onto surface L1 forms. Here I use transfer of underlying forms, surface forms and mapping from underlying to surface forms as tools for this study but these assumptions can be proven wrong by the outcome of the study. As the point of departure for the subjects in this study is a pair of languages that has context-conditioned surface realisations (i.e. [d̪] and [ð̪]) of an underlying segment /d̪/, it is important to discuss the notion of the default realisation, as it will also be used in the formulation of hypotheses.

1.6.1. The notion of the default realisation of an underlying segment

In Catalan and Spanish, there is what has traditionally been labelled as allophonic variation in the case of underlying /d̪/. When there is allophonic variation, one of the realisations is generally taken as the default realisation of the underlying segment. For Catalan and Spanish /d̪/, [d̪] has generally been taken to represent the default realisation. The dental stop is the default if we base our decision on theoretical grounds. This segment is the least restricted in terms of distribution in the output. In Fig. 1.5., [d̪] is the segment that fulfils the 'elsewhere condition', in a traditional approach to allophonic variation. Of course, the notion of the 'default' depends on our definition of what it is. If a different criterion were used to determine whether [d̪] or [ð̪] was the default, the result would be different. For example, Llisterri (1993) points out that, for Spanish, the occurrence of [d̪] in the corpus he analyses is 0.76% whereas that of [ð̪] is 3.20%. Therefore, in

terms of frequency we could state that the dental approximant [ð̞] is the default rather than the dental stop [d̪] in Spanish. However, as all the other tools used in the model presented here are taken from theoretical phonological accounts, we will stick to [d̪] as the default segment when we deal with this surface realisation of underlying /d̪/.

1.7. Our hypotheses on L2 production transfer

If we assume the existence of the phonological representations mentioned above, then the transfer processes that can occur in the production of L2 segments differ depending on whether the underlying representation or the surface realisations transfer. The main point of this thesis is to test various possibilities for the way transfer works in L2 production. The case under study focuses on the manner of articulation in L2 production when Catalan learners of English attempt to produce the L2 contrastive segments /d/ and /ð/. Catalan and Spanish serve as L1[4] and English as L2 in the examples in the following section. This specific case allows us to discern between all the different hypotheses, given that L1 has one underlying segment /d̪/ which has two different context-conditioned realisations, the default realisation [d̪] and another realisation [ð̞]. These different representations and the mapping between underlying to surface segments could transfer to L2. The hypotheses explore these different transfer patterns. As these two English segments mainly differ in manner of articulation, we describe the accuracy in production of these L2 learners in terms of this feature (i.e., stop vs. non-stop). The hypotheses we are testing follow right away.

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[4] Henceforth, Catalan will stand for both Catalan and Spanish for the sake of brevity, due to the fact that voiced dental stops and voiced dental approximants have the same distribution in both languages and thus the influence of any of the languages on L2 is similar.

1.7.1. Hypothesis 1

First, we could assume that the underlying representations in L1 transfer. We assume that L2 learners would use the L1 underlying segment with the least restricted distribution in all L2 contexts because as such it could be considered the default. L2 learners may relate the underlying representation transferred from L1 only with its default surface form in L1 (i.e. the one with the least restricted distribution in L1) because they may be aware that in another language the distribution of realisations might differ from that in their L1. This means that in our study [d̪] will surface in all productions of Catalan learners of English because it is the default surface form of /d̪/ in Catalan and Spanish.

L1	L2
/underlying segment/ $\longrightarrow$	/underlying segment/
↓	↓
[surface segments]	[L1 underlying segment in its default surface form]
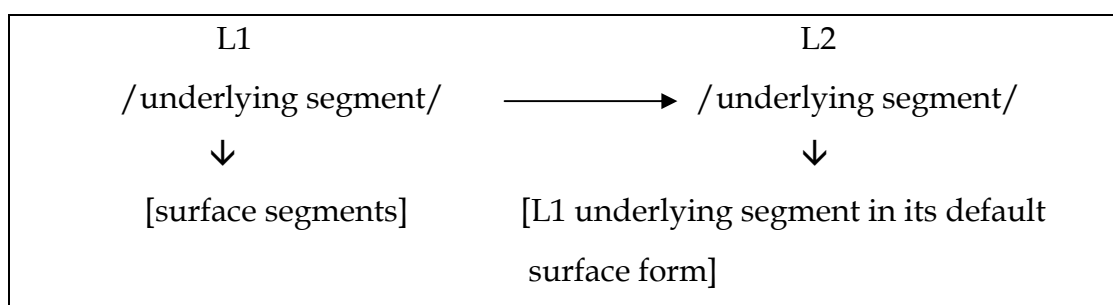
Fig. 1.6. Hypothesis 1

1.7.2. Hypothesis 2

In the previous hypothesis, we assumed that the L1 underlying segment was only produced as its default surface segment. However, the underlying segment could include all of its surface realisations (i.e. the default and the non-default surface realisations). If the underlying L1 segment is transferred, then it could surface as any of its surface realisations anytime. Therefore, the result would be free variation in the production of L2

contrastive segments, when L1 underlying segments have two different context-conditioned realisations. In the case under study, it means that any of the two surface forms could surface anytime.

L1	L2
/underlying segment/——————▶	/underlying segment/
↓	↓
[surface segments]	[L1 underlying segment as any of its L1 surface segments]
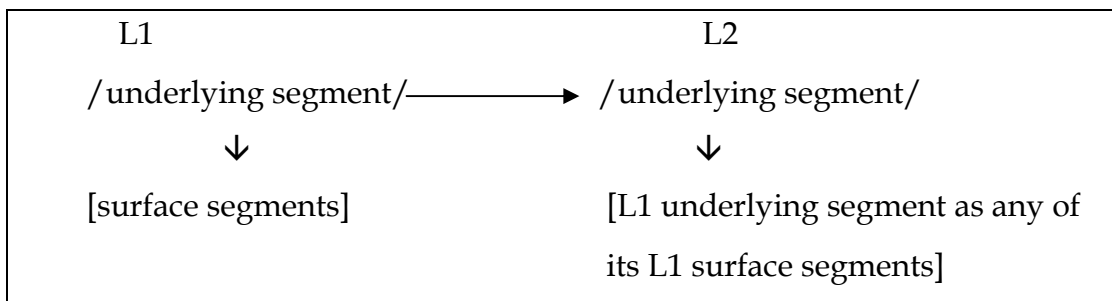
Fig. 1.7. Hypothesis 2

1.7.2. Hypothesis 3

Another possibility is that the surface realisations, and not the underlying representations of L1, transfer and are categorised as contrastive segments in L2. The surface realisations of L1 are transferred to the inventory of L2 and will form part of the L2 contrastive system. Then, these segments will be produced as such in any context due to a default realisation process. A default realisation process means that the new underlying segments can be produced in any context in the L2. This means that Catalan [d̪] and [ð] would be produced as such in any context in English. Therefore, their production would not be problematic if such transfer happens to be the case.

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┌─────────────────────────────────────────────────────────────────┐
│        L1                                    L2                    │
│                                    ↗                               │
│   /underlying segment/              /underlying segments/         │
│        ↓                                    ↓                      │
│   [surface segments]                [surface segments] in any     │
│                                     position                      │
└─────────────────────────────────────────────────────────────────┘
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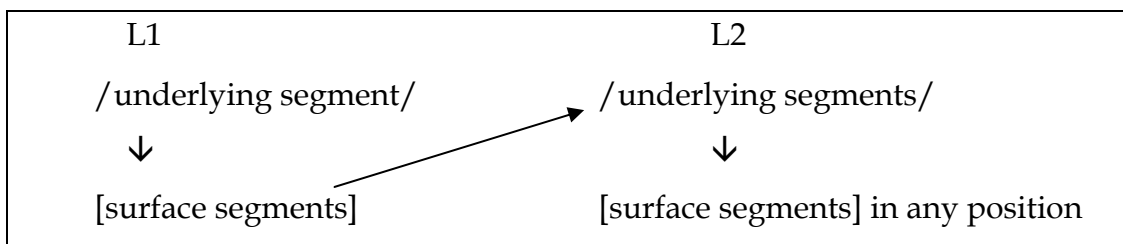
Fig. 1.8. Hypothesis 3

1.7.3. Hypothesis 4

If we have a look at the speech production process assumed in Fig. 1.1., we see that the L1 underlying-to-surface mapping might also be susceptible to transfer. In the Generative Phonology framework, this would mean transfer of the L1 allophonic rules to the L2 sound system. Therefore, if the context-conditioning present in L1 transfers, the L2 output will display output following it. If not only the L1 underlying segment but also the L1 underlying-to-surface mapping transfers, the L2 inventory would consist of the same underlying segments as those in L1 but they will only surface as the underlying segment in the contexts in which it occurs in L1. This suggests that Catalan speakers of English will transfer /ḏ/ but it will only surface as such in absolute initial position.

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┌─────────────────────────────────────────────────────────────────┐
│        L1                                    L2                    │
│   /underlying segment/  ──────→     /underlying segment/          │
│        ↓                ──────→             ↓                     │
│   [surface segments]                [as L1 default surface        │
│                                      segment                      │
│                                      only in L1 contexts]         │
└─────────────────────────────────────────────────────────────────┘
```
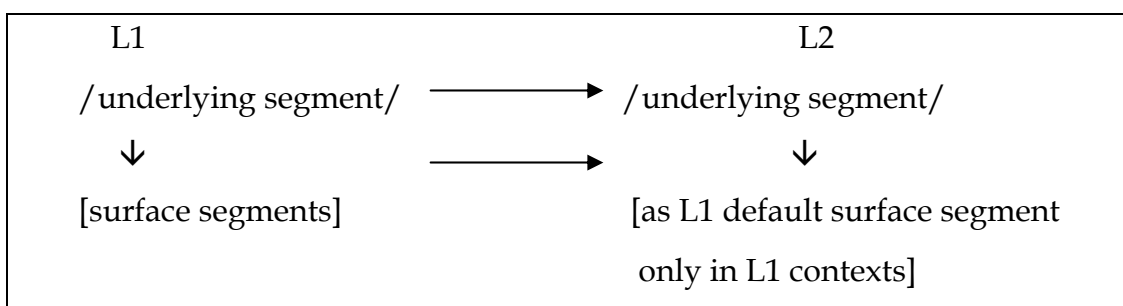
Fig. 1.9. Hypothesis 4

1.7.4. Hypothesis 5

Finally, we could combine the idea that the L1 underlying segment transfers together with the L1 underlying-to-surface form mapping. That is, the underlying segment with all of its surface forms transfers. Since the L1 underlying-to-surface form mapping will also be transferred, the surface realisations will surface only in the positions where they surface in L1. That is, Catalan learners will use their L1 segment distribution and the L2 production will be a replica of what they do in their L1. That is, [d̪] will surface in absolute initial position and [ð̞] in intervocalic position.
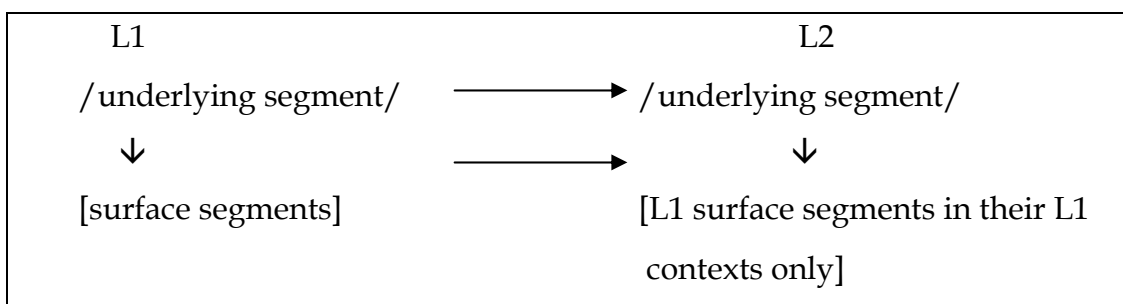
Fig. 1.10. Hypothesis 5

Such a behaviour could be accounted for, in OT terms, as though Catalan speakers transfer the L1 ranking of constraints, which lead to the L1 output patterns, onto L2. Such a scenario can arise if what is transferred involves the L1 conditions on well-formed output forms as those captured by Optimality Theory. According to OT, the grammar of a language ranks the constraints on the output in a specific way in order to choose the allowed output from a series of candidates. If the order in which the constraints are ranked in L1 are transferred to L2, then the L2 output will show the surface L1 representations or allophones only occurring in the contexts in which they surface in L1 (e.g. Hancin-Bhatt & Bhatt, 1997; Broselow et al., 1998).

1.8. Possible scenarios when learning a L2 contrast

The case we have used for illustrating the different transfer patterns is not the only possible one. When learning L2 phonology, it is crucial to learn the L2 segments which convey contrasts (i.e. phonemes). Sometimes those contrasts will coincide with those already existing in the learners' L1, but sometimes they will not. The different possible scenarios which an L2 learner could face involving a pair of L2 underlying segments which do not exactly match the L1 underlying segment/s or surface forms are described in table 1.1. below. We assume that, in such scenarios, the segments in the contrast to be learnt in L2 – where A and B stand for the target underlying segments in L2 and the equivalent segments existing in L1 – have to be similar for there to be some kind of conflict in separating the categories. Such a similarity would cause a problem that would show in production, as Flege's Equivalence Classification would predict. Therefore, the L1 system's lack of underlying segments or the L1 distribution determines that L2 speakers will merge 2 categories into one category.

Table 1.1. Scenarios showing different L1 segment distributions with respect to an L2 contrast.

		L2	L1
Scenarios	1	Underlying segments A and B	Neither A nor B
	2	Underlying segments A and B	Underlying segment A
	3	Underlying segments A and B	Underlying segments A and B, but they neutralise in some context.
	4	Underlying segments A and B	A and B are surface forms of underlying segment A

In scenario 1, neither A nor B exist in the speakers' L1 but these two segments are contrastive in L2. As an example, a study examined the production of a group of Italian speakers of English (Flege, Munro & MacKay, 1995). Their production of target initial /θ/ and initial /ð/ was not accurate and they produced /t/ and /d/ instead, respectively. Italian has none of the interdental fricatives. This suggests that they transferred an underlying segment or a surface segment from their L1 even though it is not identical to that in the target language. We cannot tell from this evidence which of our hypotheses is supported. In that study, a segment from L1 is transferred to the L2 sound system and the segment is similar to but not identical to the target L2 underlying segment. In our hypotheses, we are assuming that segments exist in both L1 and L2 but at different levels (i.e. underlying vs. surface) in each language. However, in scenario 1 none of the target segments exists in L1 at all.

In scenario 2, L1 has one underlying segment whereas L2 has two underlying segments that are similar to the L1 phoneme. This could lead to merging of the pronunciation of the two categories due to their similarity. For example, Spanish speakers of English only have a high front vowel /i/ in their L1 (i.e. Spanish /i/ is phoneme A in table 1). However, English has both /i/ and /ɪ/ (i.e. English /i/ is underlying segment A and English /ɪ/ is underlying segment B in table 1). Spanish speakers' production of the two underlying English segments in contrast tends to be as that of their native /i/. Their pronunciation of words like 'sheep' and 'ship' would be very similar. Consequently, the contrast between /i/ and /ɪ/ is lost in the production of Spanish speakers. A large amount of research in production of L2 segments has focused on the production of segments that are new to speakers of a given L1. This research provides us with some evidence about transfer but we cannot clearly discern which of our hypotheses is supported by these cases. The results in these studies can be accounted for by all of our

five hypotheses. Our five hypotheses draw the same predictions because the L2 underlying segments are not context-conditioned surface segments in L1. One of the target L2 underlying segments does not exist in L1. As an illustration, Flege (1987) studied the production of French /y/ by English speakers. This underlying segment does not exist in English. Highly experienced speakers pronounced /y/ authentically but least experienced speakers did not. Since English does not have /y/, Flege's group of least experienced speakers transfers the most similar segment in their L1, i.e. /u/, to L2. In this example, English /u/ stands for underlying segment A whereas French /u/ and /y/ stand for underlying segments A and B in L2. Another study that examined the production of totally new sounds deals with the acquisition of English segments by Hungarian speakers (Altenberg & Vago, 1983). The authors observed some systematic substitutions in the speech of Hungarian speakers of English. Hungarian speakers pronounced English /w/ as Hungarian [v], English /θ/ as Hungarian [t], English /ð/ as Hungarian [d], English [ɪ] as Hungarian [i], English /ʊ/ as Hungarian [u], and English /æ/ as Hungarian [ɛ]. Again, all these cases are accounted for by transfer of the most similar L1 segment (at the underlying level) to the L2 target sound. These results, however, do not allow us to identify what representational unit is transferred because these segments are not allophonically conditioned in Hungarian. Hungarian speakers might transfer L1 underlying or surface segments to the L2 underlying segments that do not exist in their native language and, therefore, their production of the L2 sound is not native-like. Here, all of our five hypotheses would predict the behaviour exhibited by the Hungarian speakers of English. In a study (Flege, Bohn and Jang, 1997) on production and perception of English /æ/ by Mandarin and Korean subjects, who did not have this segment, appeared to actually use some similar sounding vowel in their creation of an L2 category.

Flege et al. (1997) write that "it appears that the [æ]-quality vowels occur in certain contexts in Mandarin, and as a frequent realisation of Korean /ɛ/. One might speculate that L1 allophony hindered the Mandarin and Korean subjects." (p. 457) Therefore, it seems that certain context-conditioned categories of L1 could also negatively interfere in the production of L2 segments. Nevertheless, they do not provide any further information about the contexts in which these L1 vowels with a similar quality occur. This vowel (/æ/) appears in very specific contexts (e.g. before alveolar consonants, in closed syllables but not before nasals), in Mandarin Chinese, which coincide with some of the contexts in which the vowel occurs in English. In this case, the fact of having a given context-conditioned surface form in their L1 interferes negatively in their creation of an L2 underlying representation for that segment.

Scenario 3 presents the case of contextual neutralisation. For example, German has pairs of voiced and voiceless stops as underlying segments. However, this distinction is lost in word final position. When German speakers learn English, the final stop voicing distinction could be lost due to the influence of their L1 pattern. As an example, they might have problems in producing the distinction between 'cab' and 'cap'. They might only produce a voiceless stop in final position. Since German both voiced and voiceless stops conform a lexical contrast but German speakers of English display an L2 surface pronunciation which matches their L1 surface pronunciation patterns, perhaps not only the units in L1 and L2 are crucial in determining the accurate production of target L2 segments. The context in which segments occur in L1 could also be a factor in determining native-like pronunciation of L2 segments only in certain contexts. In one study, some facts in the English pronunciation of an Icelandic speaker (Hecht & Mulford, 1982) provide further evidence for the importance of mapping. Steinar, an Icelandic boy who acquired English in the US, produced final English voiced

stops as "devoiced and heavily aspirated, as are final stops in Icelandic (Einarsson, 1945, p. 23)" (p. 324) As another illustration, Cebrián (2000) examined whether Catalan speakers managed to produce final voiced stops authentically, since Catalan only allows final voiceless stops. He found that final devoicing was present in their English speech. This provides evidence in favour of hypothesis 4 (i.e. transfer of L1 Underlying Segment as Default Surface Segment with L1 Underlying-to-Surface Mapping) or hypothesis 5 (i.e. transfer of L1 Underlying Segment as any L1 Surface Segment with L1 Underlying-to-Surface Mapping). The two hypotheses draw the same predictions because both voiced and voiceless stops are underlying segments in Catalan, so they have both the status of default surface segment and also of any L1 surface realisation. This case shows the importance of context even though the status of the elements that are transferred is not clear because both voiced and voiceless stops are underlying segments and surface realisations in L1. The only problem is that the L1 surface realisations only occur in some contexts which do not match with all the contexts in which those same realisations occur in L2.

Finally, the fourth scenario proves to be particularly difficult to L2 learners (Lado, 1957; Stockwell & Bowen, 1965, 1983). In these cases called "allophonic splits" (Gierut, 1986; Hardy, 1993; Eckman & Iverson, 1997; Eckman et al., 2003), two surface forms of one underlying segment in the L1 stand for two separate underlying representations in the L2. When two segments exist in learners' L1 but they do not have a contrastive role in that language whereas they stand for a two underlying segments in contrast in L2, this constitutes a major obstacle in the mastering of the contrast. The inaccurate pronunciation of the contrast might give way to possible misunderstandings when using L2. The fact that two segments are contrastive in L2 but not in L1 causes L2 learners a good deal of trouble to make the L2 distinction. For example, Korean has one underlying segment /s/ with two different surface realisations: [s] and [ʃ]. The palato-alveolar

fricative only occurs before the vowel [i] in Korean (Iverson, 1993). This allophonic conditioning of [s] and [ʃ] differs from the contrastive role that these two underlying segments have in the English system. Potential problematic cases for them are those in which Korean speakers of English have to produce English words in which these segments are minimal pairs (e.g. 'sheen' vs. 'seen'). The Korean speakers who transferred the Korean context-conditioning of the surface forms to English pronounced target 'seen' as [ʃin]. In such cases, the context in which segments occur in L1 and L2 is a factor to be borne in mind to try and account for their production. This production can be accounted for by hypothesis 5 (i.e. transfer of the L1 Underlying Segment as any L1 Surface Segment with L1 Underlying-to-Surface Mapping). Brière (1968) also studies a case involving an allophonic split. He found that speakers of American English had more problems in learning to pronounce [tʰ] than [t] in the contexts where these segments do not occur in English. In English /t/ is an underlying segment or the surface segment with the widest distribution (e.g. as in 'stop' [stɒp]) whereas [tʰ] (e.g. as in 'top' [tʰɒp]) is an surface form of /t/ in initial position). In Brière's study the target language – Vietnamese – has /t/ and /tʰ/ as underlying segments, and they occur as such in all positions. American English speakers pronounced /t/ in initial position more accurately than /tʰ/ in non-initial position (i.e. in the new positions). However, these results are consistent with our first hypothesis (i.e. transfer of L1 Underlying Segment as Default Surface Segment). Such a hypothesis predicts that the default surface segment, if we take the surface segment without a diacritic to be the default (i.e. /t/), is transferred and it will be produced as such regardless of the context in L2. The results in Eckman & Iverson (1997) and in Brière (1968) are not consistent with each other and, therefore, they are accounted for by different hypotheses.

There are several aspects we should be cautious about in claiming that the findings in Brière's study could apply to all L2 learners, though, because of the specific conditions for his experiment. His L2 setting is somewhat artificial. Monolingual speakers of American English served as subjects in his study, and some of them had formally studied Latin, Spanish or Italian as a foreign language. Subjects were chosen according to their phonetic ability. They all took the Eunice Pike test, which is a phonetic ability predictor, and only the ones with the highest scores were recruited to act as subjects. Brière's findings do not represent a random sample of population. Brière analysed the production and perception of a selected group of phonetically 'gifted' subjects. Of course, if we obtain these results in the production and perception of 'phonetically gifted' subjects, chances are that the problems in production and perception will be even more extreme in average L2 learners. What does not represent average L2 learning could be the setup of the test in Brière's study. Subjects in his study took the Eunice Pike test, in which subjects were asked to mimic strings of sound that contain some phones that are not part of the American English sound system. That is some kind of artificial learning context. In order to try and find out what the results in a real L2 learning context are, we ran experiments that did not involve training but intend to show what average L2 learners' production and perception are like. Therefore, we predict that a behaviour like that of the subjects in Iverson's study is more likely to be observed than that in Brière's. That is, it is more likely for our data to be consistent with hypothesis 5 than with hypothesis 1.

1.9. Why did I choose to study the allophonic split?

In my experiments, I analyse the perception and production of L2 learners whose L1 has two surface segments which are different underlying segments in L2. Such a case has traditionally been called allophone splitting.

According to Flege's terminology (1987), the English /d/ and /ð/ would stand for similar phones to those bilingual speakers of Catalan and Spanish have in their L1 (i.e. [d̪] and [ð̞]). He describes similar L2 phones as "an L2 phone which is realized in an acoustically different manner than an easily identifiable counterpart in L1 (p. 59). The equivalence classification mechanism would prevent bilingual speakers of Catalan and Spanish from creating two separate new categories in their English interlanguage. Flege's classification considers this contrast to be difficult to master. In the traditional nomenclature for such a scenario as allophone splitting, it has also been reported to be the most problematic case for L2 learners to overcome (Lado, 1957[5]; Stockwell and Bowen, 1965, 1983; Hammerly, 1982; Hardy, 1993 – as reported in Eckman et al., 2003; Eckman et al., 2003). In a similar way, L1 neutralisation seems to be quite difficult for learners to avoid in L2 production (Cebrián, 1997). If we look at the allophonic splitting case we used to illustrate the transfer possibilities (i.e. Catalan speakers producing the English /d/ and /ð/) and the case of contextual neutralisation (i.e. German speakers producing both English final /b/ and /p/ as [p] only), we observe that they have in common that the context in which segments occur in L1 could play a crucial role in predicting the accurate production of L2 underlying segments. In terms of markedness, we could say that the outcome of the L1 phonological processes (i.e. spirantisation and neutralisation, respectively) is an unmarked output.

The advantage of the allophonic split case over the contextual neutralisation is that, given our five different hypotheses for transfer processes, the former enables us to distinguish five different predictions

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[5] Lado stated that "when one significant unit or element in the native language equates bilingually with two significant units in the foreign language we have maximum learning difficulty" (1957, p. 15), even though such a statement did not agree with his main hypothesis. His main hypothesis postulated that 'new is difficult'. Therefore, if the L2 has two sounds which already exist in the L1 but differently organised should be relatively easy to produce and perceive.

whereas the latter only provides us with three different predictions. The difference between these cases is that in the allophonic splits both L1 segments (i.e. [d̥] and [ð̥], in our example) are surface realisations and only that with the widest distribution (i.e. [d̥]) is the one that is an underlying segment too. On the other hand, the L1 phones in the contextual neutralisation (e.g. German [p] and [b]) are both underlying and surface segments, even though only one of them (i.e. [p]) surfaces as such in final position. Therefore, hypotheses 1 (i.e. transfer of L1 Underlying Segment as Default Surface Segment) and 3 (i.e. transfer of L1 Surface Segments) predict the same for the contextual neutralisation case. Similarly, hypothesis 4 (i.e. transfer of L1 Underlying Segment as Default Surface Segment with L1 Underlying-to-Surface Mapping) and hypothesis 5 (i.e. transfer of L1 Underlying Segment as any L1 Surface Segment with L1 Underlying-to-Surface Mapping) make the same predictions for the case of German speakers producing English /b/ and /p/. Let us take two contexts for production of /b/ and /p/ which, like in the case of Catalan speakers of English, correspond to L1 contexts and also contexts in which not all of them occur in German. In initial position both [b] and [p] occur. However, in final position both stops surface as [p]. In such a case, hypothesis 3 (i.e. transfer of L1 Surface Segments) predicts that German speakers will transfer their L1 allophones [b] and [p] to their L2 system and will also pronounce them as the target English segments regardless of the context. That is, they will pronounce '[b]an' with a voiced stop and '[p]an' with a voiceless stop, as well as 'ca[p]' (with a voiceless stop) and 'ca[b]' (with a voiced stop). This prediction is exactly the same as the prediction by hypothesis 1. Since /b/ and /p/ are different underlying segments in German, /b/ is transferred and surfaces as its less restricted surface segment (i.e. [b]) in all contexts. The voiceless bilabial stop /p/ will also be transferred and will

surface as such in all positions. The convergence in predictions by these two hypotheses in the contextual neutralisation is one of the reasons why allophonic splits are more informative in terms of explaining the transfer processes between L1 and L2 than contextual neutralisation cases. At this point we have the necessary background to discuss the second reason why we opted for choosing the allophonic split over the contextual neutralisation for our study. Again, the predictions made by hypotheses 4 and 5 are the same. Hypothesis 5 (i.e. transfer of L1 Underlying Segment as any L1 Surface Segment with L1 Underlying-to-Surface Mapping) predicts that the L2 output will reflect the L1 production patterns. Therefore, German speakers of English will produce '[b]an', '[p]an' and 'ca[p]' as they are to be pronounced in English, but they will produce 'ca[b]' with a final devoiced stop, as final German stops are. If we have a look at the prediction by hypothesis 4 (i.e. transfer of L1 Underlying Segment as Default Surface Segment with L1 Underlying-to-Surface Mapping), we realise that the output would be the same. Both German /b/ and /p/ underlying segments will transfer to L2, with [b] as the default surface realisation of /b/. However, the L1 Underlying-to-Surface Mapping is also transferred, and therefore /b/ will be realised as [p] in final position due to the German final devoicing rule.

The Catalan allophone splitting case provides us with an ideal testing ground to discern which transfer pattern occurs when a speaker whose L1 lacks a L2 contrast. Catalan speakers' production of English /d/ and /ð/ in absolute initial (i.e. context in which Catalan /d/ surfaces as a stop) and in intervocalic position (i.e. context in which Catalan /d/ surfaces as an approximant) is examined in this thesis.

Apart from that, Catalan also provides us with another case we can use as a control for the output we obtain for /d/ and /ð/. Spirantisation in

Catalan affects not only /d/ but all the voiced stops. Therefore, Catalan /b/ is pronounced [β] in intervocalic position in all dialects. The voiced bilabial approximant /β̞/ is not an underlying segment in English but the voiced labiodental fricative /v/ is. The Majorcan Catalan dialect differs from Central Catalan in that the former has /v/ as a contrastive segment whereas the latter does not. Therefore, we are able to compare the production of English /b/ and /v/ by speakers who have both as contrastive underlying segments in their L1 (i.e. Majorcan Catalan) and those who only have /b/ as an underlying segment in their L1 (i.e. Central Catalan). Regarding /b/ and /v/, the Majorcan Catalan's phonemic system is the same as the English but the difference lies in the fact that Catalan /b/ surfaces as an approximant in intervocalic position. On the other hand, Central Catalan has /b/ as a phoneme, like English, but Catalan /b/ surfaces as such in absolute initial position but spirantises to [β̞] intervocalically. The voiced labiodental fricative /v/ is not a segment in Central Catalan. The analysis of production of /b/ and /v/ in absolute initial and intervocalic position by Majorcan and Central Catalan speakers could provide us with further evidence on how transfer works in two scenarios. Majorcan Catalan speakers of English illustrate the scenario in which both L2 underlying segments /b/ and /v/ are also two different underlying segments in L1 but one of them (i.e. /b/) has two different surface realisations (i.e. [b] and [β̞]) in L1 whereas it is only realised as [b] in L2. On the other hand, Central Catalan speakers of English illustrate the scenario in which two underlying segments /b/ and /v/ are learnt by speakers whose L1 only has one of the phonemes, namely /b/, which has two realisations in complementary distribution (i.e. [b] and [β̞]) and lacks the underlying segment /v/. The results for the data on /b/ and /v/ were in the end discarded from this thesis due to difficulties and

incongruence in the analysis. However, we cannot deny the fact that the case it presented was interesting due to its specific L1-L2 mapping scenario.

1.10. Another possible factor playing a role in L2 production: the morphological configuration of words

The accuracy in production of L2 underlying contrastive segments could be determined not only by the distribution of those underlying segments in L1, but also by the morphological configuration of L2 words in which those L2 underlying segments occur. Two different morphological factors could be responsible for accuracy in production of L2 underlying segments: the occurrence of the target L2 underlying segment in derived or non-derived environments or the occurrence of the target L2 underlying segment at prosodic word boundaries.

In Lexical Phonology, it was shown that processes affect derived and non-derived words differently. For example, the velar softening process, by which a voiceless velar stop becomes a fricative, occurs in the alternation 'electric' /ɪˈlɛktrɪk/ ~ 'electricity' /ɪlɛkˈtrɪsɪtɪ/ but not in 'king' /kɪŋ/ (i.e. we do not obtain /sɪŋ/). The difference is due to the fact that 'electricity' is a derived word whereas 'king' is not and cannot, therefore, undergo the velar softening process, which is a lexical process. While L2 phonology is known to be influenced by the rules and processes of the learner's L1, not all L1 patterns transfer to L2 to the same extent. Some studies indicate, for instance, that postlexical processes of L1 are more likely to affect L2 than do lexical alternations (Altenberg & Vago, 1983; Weinberger, 1994; Zsiga, 1995). Moreover, effects of postlexical processes do not appear equally in all L2 contexts that satisfy the conditions of the application (Major

& Faudree, 1996; Cebrián, 2000). Assuming that rules exist, and by combining all the different possibilities of L1 postlexical rule transfer to L2 interlanguage, L1 postlexical rules can target:

(i)   both derived and non-derived contexts

(ii)   only derived contexts

(iii)   only non-derived contexts, or

(iv)   none of them (i.e. the rule is eliminated)

In an attempt to characterize the L2 contexts that are more prone to L1 transfer, Eckman and Iverson (1997; also Eckman et al., 2003) hypothesized that (i), (ii) and (iv) could be the case but ruled (iii) out, since it is less likely for postlexical L1 processes to affect L2 lexical entries only. In support of their hypothesis, none of the Spanish-speaking learners of English in their study showed a higher rate of intervocalic spirantisation in non-derived English words (e.g., 'la_dd_er') than in derived words (e.g., 'ma_dd_er'). That is, the data were consistent with case (ii) in that they showed spirantisation in derived words more often than in non-derived words. The difference in rate between spirantisation in derived and non-derived words makes case (ii) a more accurate description of their subjects' production than (i).

If we apply this to our Catalan-Spanish speakers of English who also have spirantisation rule in both of their L1, we might find that they apply their L1 spirantisation rule to (i) both derived and non-derived contexts, or to (ii) derived contexts only (i.e. to 'ma_dd_er', but not to 'la_dd_er'), or to (iii) non-derived contexts only (i.e. to 'la_dd_er', but not to 'ma_dd_er'), or to (iv) none of them, when speaking English.

Another account for this kind of data considers that accuracy in production of a target L2 underlying segment could differ depending on whether we assume that there is a prosodic boundary at the end of the stem in derivation (Aronoff & Sridhar, 1983). This Morphology-Prosody Edge

Alignment approach would predict different behaviour in the production of L2 underlying segments that happen to be at prosodic boundaries. This approach assumes that there is a prosodic word boundary at the end of stems of words (i.e. at the end of 'ladder' and at the end of 'mad'). If the prosodic boundary favours spirantisation, then our subjects will spirantise /d/ in derived words like 'madder' but not in non-derived words like 'ladder' (i.e. case (ii) above.) On the other hand, if the boundary prevents spirantisation from applying, then we will find that our subjects will spirantise /d/ in non-derived words like 'ladder' but not in derived words like 'madder (i.e. case (iii) above.) If prosodic boundary does not play a role in production of /d/, then we will either find that spirantisation affects both 'ladder' and 'madder' (i.e. case (i)) or it affects neither (i.e. case (iv.)

In order to test whether the morphological configuration of words affects the production of intervocalic English /d/, the production test will include both monomorphemic words with target /d/ in intervocalic position (e.g. 'ladder') and polymorphemic words with target /d/ in intervocalic position (e.g. 'madder').

By testing whether rules are transferred to L2 and whether the morphological configuration of words determines the transfer of these rules, we will have a clearer picture of transfer in L2 production. We ran a pseudo-replication of Eckman and colleagues' experiments (1997, 2003) because their studies lack statistical treatment of the data. Therefore, their findings indicate trends but it cannot totally be asserted that the difference in rate of spirantisation in derived and non-derived words is statistically significant. The data and results of the polymorphemic production test are reported in Chapter 5.

1.11. Structure of the thesis

The present chapter has introduced the main issues, concepts and motivation of the thesis, plus a review of the relevant literature on phonological transfer in L2 production.

Before dealing with the production of /d/ and /ð/, Chapter 2 will describe the identification of these English segments by Catalan-Spanish speakers of English and compare it to the identification of these segments by English speakers. This will provide us with a description of the perception skills of Catalan-Spanish speakers of English. Their perception of /d/ and /ð/ will be compared with the production of each one of these English segments in the following chapters.

Chapter 3 will then show the methodological strategy used in the production experiments and the way we dealt with the data analysed by transcribers.

Chapter 4 details the production experiment on mono-morphemic words. This chapter will help us discern which of the five hypotheses put forward in this thesis is more appropriate to explain our results. The experiment's design and the case in point will provide us with an ideal set of data to know what is transferred from L1 onto L2.

Chapter 5, in turn, deals with the production experiment on poly-morphemic words. It will help us find out whether the morphological configuration of words plays a role in the accurate production of specific segments.

Finally, Chapter 6 presents a summary and discussion of the findings, and the conclusions of the thesis.

CHAPTER 2

PERCEPTION EXPERIMENT

This perception experiment was conceived of as a baseline with which to compare the production experiments (the main focus of this thesis). As we pointed out in the literature review, production and perception are two strongly linked skills. Most studies examining the relationship between these two skills have shown that mispronunciation of given segments in L2 is due to the misperception of such sounds (Cortés, 1999a; Cortés, 1999b; Flege, 1993; Flege et al., 1999; Neufeld, 1988; Rochet, 1995; among others). However, this is not always the case. Some subjects have proven to be better at producing specific segments than at perceiving them (Brière, 1968; Goto, 1971; Sheldon & Strange, 1982). The perception of L2 segments might play a crucial role in the way they are pronounced. In order to be able to state whether the behaviour our subjects display in production is due to the way they perceive the English contrast or not, we wanted to check whether accurate/non-accurate production of the segments under study in this thesis was conditioned by accurate/non-accurate perception of the target segments in the target positions. Therefore, we devised an identification test to find out how Catalan-Spanish bilingual listeners identify English /d/ and /ð/ both in absolute initial and intervocalic position.

2.1   Method

2.1.1. Stimuli in a pilot identification test

In the pilot study for the perception test, we created some stimuli by recording 4 native speakers of English (2 male and 2 female speakers, one of each gender being an American English speaker and the other a British English speaker). This was so that none of the subjects listening to the items would be favoured if they were more used to one of these varieties, or to male vs. female voices. The recorded speakers read words that were members of a minimal pair involving the contrasts /d/ and /ð/, and /b/ and /v/ in absolute initial and intervocalic positions. The bilingual listeners in Catalan and Spanish were presented with a questionnaire presenting the two members of the minimal pair exhibiting the target contrasts. For example, they were presented with the pair 'van-ban' when they were presented with one word in the pair and were asked to circle what they thought they had heard. When analysing these data, we noticed a frequency effect in the data. Listeners tended to choose the most frequent word in the pair. For example, in the 'van-ban' pair they showed a preference for 'van' over 'ban' no matter what the stimulus was. In order to get rid of this frequency effect, we decided to use nonsense words as stimuli in our final version of the perception test.

2.1.2. Stimuli in the final identification test

The eventual stimuli for the perception test consisted of a set of phonotactically possible English words combining one of the consonants under study with one or two vowels. The syllable combinations had /d/ and

/ð/ in initial or intervocalic position. When in initial position, these consonants were followed by one of the vowels /a/, /i/ or /u/. When in intervocalic position, the target stop and the fricative were both preceded and followed by the same vowel. Thus, the context in which the phones occur is controlled for vowel coarticulation effects. In such cases, one repetition carried the stress on the first syllable whereas the other one had a stressed second syllable. For example, the resulting complete set of stimuli containing /d/ was:

/da/ /di/ /du/ /'ada/ /a'da/ /'idi/ /i'di/ /'udu/ /u'du/

These stimuli were played in isolation. These non-existing but possible English syllable combinations are likely to be free from the frequency effect obtained in the pilot study.

Again, the same four native speakers of English were recorded onto DAT tape in a sound-treated studio. Two of them were male and the other two were female. One male and one female speaker were speakers of American English and the other two were British English speakers. Each speaker read the items in both sets of stimuli twice. These stimuli were downsampled onto hard disk and separate sound files were made for each stimulus. They were also digitised at a sampling rate of 16 kHz using Sun Ultra 1 with X-Waves software; then, they were randomised and, finally, a one-second pause was added between items and a three-second pause was added after every tenth item. The final configuration was transferred to DAT tape.

2.1.3. Subjects

For this study, we analysed the identification of an experimental group and a control group of ten native English listeners. The experimental group was formed by bilingual speakers of Catalan and Spanish who had an advanced level of English. Whenever bilinguals serve as subjects in linguistic research, the issue of language dominance arises. That is, they might not be equally proficient in both of their L1s. For example, research has shown that Catalan-Spanish bilinguals who are dominant in Catalan discriminate between the Catalan vowels /ɛ/ and /e/ in perception, whereas those bilinguals dominant in Spanish do not (Pallier et al., 2001; Sebastián-Gallés & Bosch, 2003). Thus, the sole fact of being immersed in the Catalan-Spanish bilingual educational system does not guarantee that both phonological systems will be acquired and they might be more proficient in one language than the other. All of the subjects that took part as subjects in the experiments reported in the present thesis were bilingual speakers with differences in language dominance. Most of them reported coming from families where one of the parents was a speaker of Spanish and the other a speaker of Catalan and some of them came from families where both parents were Catalan speakers. All of these bilingual speakers were addressed by the experimenter in Catalan before the experimental session started and none of them showed any peculiarity in their speech that would tell that they were dominant in Spanish. Besides, as the distribution of [d̪] and [ð̪] is exactly the same in Spanish and Catalan, the difference in language dominance should not affect the way they perceive or produce English /d/ and /ð/. Due to the fact that Spanish speakers also have /θ/ in their system, all productions of [θ] were discarded from the production data. This issue is addressed in the production chapters as it directly affects the analysis of the data. Because of all these reasons, the bilinguals who took part in the perception and

production experiments are considered to be a homogeneous group and their language dominance is not a relevant issue for the acquisition of the contrast under study.

Ten native Central Catalan and Spanish bilingual listeners (9 females, 1 male), ten native Majorcan Catalan and Spanish bilingual listeners (9 females, 1 male) and ten native English listeners (9 females, 1 male) served as subjects[1]. The Central Catalan subjects (mean= 33 years, range 20 to 58 years) were studying English at a language school in Barcelona whereas the Majorcan Catalan listeners (mean= 25, range 18 to 32 years) were studying in a language school in Palma. All of them had passed exams that correspond to the First Certificate in English (FCE) exams and were about to finish their Certificate of Advanced English (CAE) courses. The English listeners (mean=27.5, range 18 to 52 years) were students in the department of Theoretical and Applied Linguistics in the University of Edinburgh. All of the subjects were adults and reported having normal hearing. They were paid for their participation.

The Catalan listeners who had visited English speaking countries for long periods of time were excluded from the study. The longest time the students included in the experiment reported having spent in an English speaking country was eight weeks. None of these informants had ever taken a course in phonetics. This was important because the aim of this project is to find whether students with a high level of English really acquire English sounds without these segments being explicitly taught. Subjects were not asked before taking part in the study whether they had ever taken a course on phonetics because doing this would have affected the outcome of the experiment as the goal would be obvious to them. Besides, they were very unlikely to have ever taken such a course as they were students of English at

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[1] Henceforth, the bilinguals in Catalan and Spanish who served as subjects in our different experiments will be only referred to as Catalan listeners/speakers for the sake of brevity.

language schools and not at university. This question, however, was asked at the very end of each interview, in a questionnaire (see Appendix A).

2.1.4. Procedure

Subjects were individually tested in the best possible acoustic conditions available. Most interviews to the Catalan listeners were held in a classroom in their own language school and the rest were held in a room in a private flat in Barcelona and in Palma. The rooms were quiet, in general, but outside loud noise such as ambulances passing by and other unexpected noises were unavoidable. In those cases, the experimenter asked the subjects to stop and go on with the test after the noise was over. The native English listeners took the perception tests in the Phonetics Laboratory of the department of Theoretical and Applied Linguistics in the University of Edinburgh.

Subjects were asked to identify the consonants on the stimulus tape as either /d/ or /ð/, as indicated on the answer sheet. They were explicitly told that the consonants they had to identify were English consonants and that the stimuli were not real words but syllable combinations. Informants were asked to circle the sound they thought that corresponded to the item they had heard. Since the experimental subjects were not linguistically trained, they were given the spellings <d> and <th> for them to choose from. At the top of each page in the answer booklet, some examples of English words starting with the voiced dental fricative were given for reference, e.g. <th> they. This was due to the fact that the spelling <th> might correspond to either the voiced or the voiceless dental fricative, in English, and we wanted them to consider <th> as a grapheme for the voiced dental fricative.

Before listening to the whole set of stimuli, subjects were explicitly told that there was one target consonant per stimulus and the position in

which they would hear the target consonants (i.e. initial and intervocalic position).

The subjects in the experimental group took the identification test after taking part in the production study on monomorphemic words, described in Chapter 4. Thus, the comparison between subjects' identification and production of /d/ and /ð/ follows a matched subjects design.

2.1.5. Equipment

The stimuli were played on a Sony TCD-D8 DAT recorder and informants listened to them through Sennheiser HD433 headphones. Informants were allowed to adjust the volume to a comfortable level.

2.1.6. Analysis

After running a mixed ANOVA test with L1 – as a between-subjects factor – and Contrastive L2 Segment and Position – as within-subjects factors – , we ran some planned comparisons that were relevant because of the predictions made by our hypotheses. Within-groups planned comparisons were run between initial and intervocalic /d/, between initial and intervocalic /ð/, between initial /d/ and initial /ð/, and between intervocalic /d/ and intervocalic /ð/ within each group of listeners. Furthermore, between-groups planned comparisons were run in order to test whether the identification of a specific underlying target segment in a given position was significantly different between native English listeners and Catalan advanced learners of English.

2.2. Results and discussion

The number of correct identifications of each English contrastive underlying segment was counted and converted into percentages.

2.2.1. Results for perception of /d/ and /ð/

Table 2.1. Percentage of correct identification of /d/ and /ð/ by Catalan and English listeners.

		Position	
	L1	Initial	Intervocalic
/d/ heard as /d/	Catalan	73.28% 351/479 s.d. 16.56	75.16% 720/958 s.d. 16.08
	English	98.75% 237/240 s.d. 2.81	99.79% 479/480 s.d. 0.66
/ð/ heard as /ð/	Catalan	74.37% 357/480 s.d. 18.35	66.1% 634/959 s.d. 18.5
	English	97.5% 234/240 s.d. 5.27	99.37% 477/480 s.d. 1.4

In table 2.1. we observe that the percentages in initial and medial /d/ and initial /ð/ are above 70% whereas intervocalic /ð/ is the one that is slightly more difficult for Catalan listeners to identify. However, the Catalan

listeners identify /d/ and /ð/ in initial and intervocalic position above chance level (initial /d/: [t (19) = 6.287, p< .001]; intervocalic /d/: [t (19) = 6.996, p< .001]; initial /ð/: [t (19) = 5.939, p< .001]; intervocalic /ð/: [t (19) = 3.891, p= .001]; The group of native English listeners behaves as expected: they identify the two consonants almost at the 100% level.
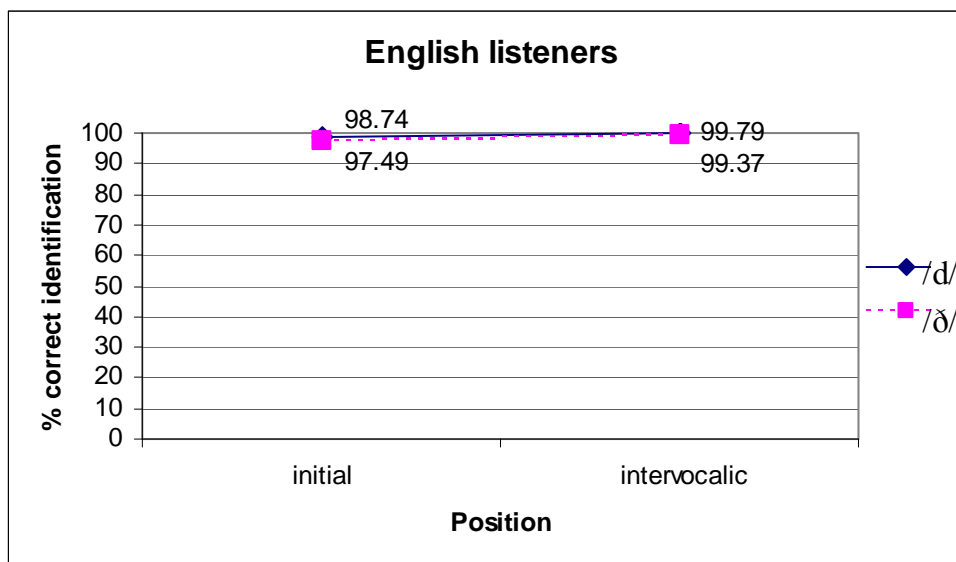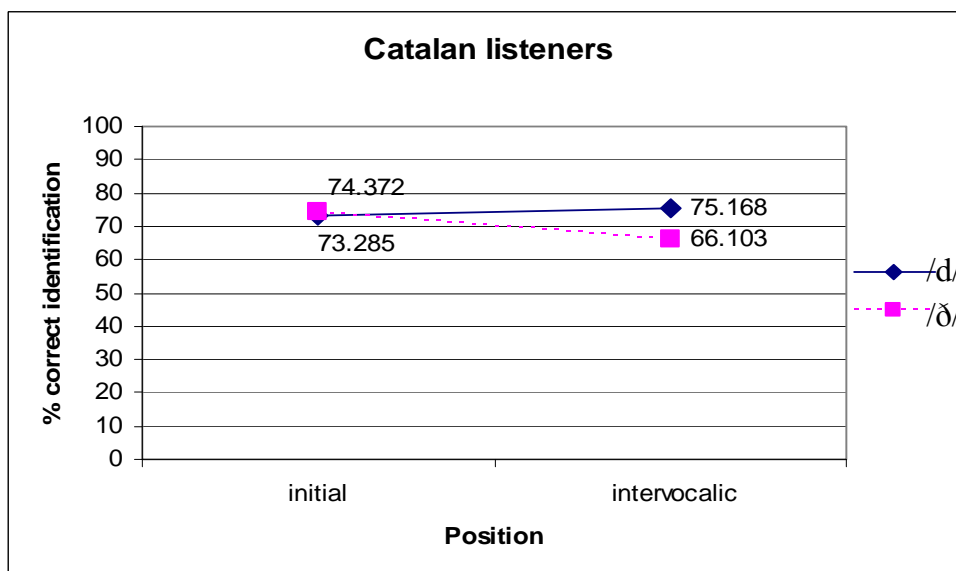
Figure 2.1. Total correct identification of /d/ and /ð/ by Catalan and English listeners.

Figure 2.1. presents the mean results in the identification test by Catalan (both Central and Majorcan Catalan) and English listeners.

The data was analysed using a mixed repeated measures ANOVA, with a between-subjects factor, namely L1, and two within-subjects factors, namely Contrastive L2 Segment and Position. The ANOVA revealed that the only interaction that tended towards significance was the Position x L1 interaction [F (1, 28) = 3.184; p= .085]. This tendency towards significance indicates that Catalan and English listeners perceive /d/ and /ð/ differently in different positions. The only effect that reached significance was L1 [F (1, 28) = 42.01; p < .001]. English listeners identify these consonants better than Catalan listeners, in general.

Several planned comparisons were run. The nature of our hypotheses led us to plan within-groups comparisons (i.e. identification of different contrastive L2 segments in different positions by the same group) and between-groups comparisons (i.e. identification of a specific phone in a specific position by different groups).

In the within-groups comparisons, only the difference in identification of /ð/ in initial and intervocalic position by Catalans reached significance: [F (1, 19) = 7.553; p = .013]. Catalan listeners seem to be better at identifying /ð/ in initial than in intervocalic position, perhaps because the higher proportion of intervocalic [ð] assigned to [d] than vice versa might reflect the fact that [ð̞] is a surface realisation of /d̪/ in Catalan. Catalan intervocalic /d̪/ is realised as approximant [ð̞], and that must be the reason why they choose /d/ instead of /ð/ for intervocalic [ð]. Finally, the comparison between identification of intervocalic /d/ with intervocalic /ð/ showed a tendency towards significance: [F (1, 19) = 3.546; p = .076]. Catalan listeners tend to identify intervocalic [d] slightly better than intervocalic [ð]. They seem to assign [ð] realisations to /d/ because Catalan intervocalic realisations of

/d̪/ are spirantised. However, when they hear an intervocalic stop they seem to notice that it cannot be an intervocalic /ð/ and identify it as a realisation of /d/.

Table 2.2. Between-groups comparisons of correct identification of /d/ and /ð/.

	Comparison	One-way ANOVA results
Catalan vs. English listeners	Initial /d/	$F_{(1,28)} = 22.907$; $p < .001$*
	Intervocalic /d/	$F_{(1,28)} = 22.992$; $p < .001$*
	Initial /ð/	$F_{(1,28)} = 15.016$; $p = .001$*
	Intervocalic /ð/	$F_{(1,28)} = 31.669$; $p < .001$*

As already hinted by the fact that L1 factor reached significance in the mixed-design ANOVA, the identification of /d/ and /ð/ by Catalan as compared to English listeners reached significance in all cases. This means that the identification of these two English consonants was always better for our English than for our Catalan listeners regardless of whether /d/ and /ð/ were in intervocalic or initial position.

2.3. Summary and conclusions

Our results confirm that English listeners are more accurate in identifying the English consonants /d/ and /ð/ in any position than the Catalan listeners. All the between-subjects comparisons show that the identification of /d/ and /ð/ is better for native English listeners than for Catalan listeners (see Table 2.2.). The Catalan subjects in the experiment are advanced learners of English but they still show some problems in correctly identifying the target English consonants. One of the only significant differences found was between the production of initial and intervocalic /ð/. Surprisingly, /ð/ was better perceived in initial than in intervocalic position. Given that /ð/ only occurs in intervocalic position in Catalan, we predicted that it would have been the other way round, that is, that Catalan listeners should have identified intervocalic /ð/ better than initial /ð/. This peculiar result might have to do with the nature of the task. Since the perception test was an identification test, the subjects might have followed a kind of elimination strategy. When presented with /ð/ items in intervocalic position and asked whether the items were instances of /d/ or /ð/, then they might just assign them to /d/ because that is the way intervocalic Catalan and Spanish /d/s are produced. However, in initial position they might look for some kind of different sound from /d/ when asked to allocate instances of /ð/ in initial position. Where our Catalan subjects have most problems is in identifying intervocalic [ð]. They tend to assign intervocalic [ð] to /d/ because that is the way intervocalic /d/s surface in Catalan.

Our goal was to compare the results for this perception experiment with the results of the production experiment. Catalan listeners'

identification of /d/ and /ð/ is worse than that by native listeners, although they identified these sounds correctly in above 65% of the cases.

We will discuss the results in relation to the production of /d/ and /ð/. We might see some parallel behaviour or very dissimilar behaviour in these two skills, so that we can contribute some more to the literature on the relationship between them.

CHAPTER 3
METHODS

The previous chapter has shown that identification of /d/ and /ð/ for Catalan speakers of English is similarly accurate be it in initial or intervocalic position, but only /ð/ was more accurately identified in initial than intervocalic position. The present and following chapters aim at finding whether the production of these Catalan speakers of English can be explained not in terms of their identification of the English contrastive segments in these contexts, but in terms of transfer processes from L1 to L2 during L2 speech production.

The point of this thesis is to check whether the way Catalan speakers produce /d/ and /ð/ is good enough for native speakers to notice the difference between stops and consonants produced with a weaker manner of articulation (i.e. non-stop, so they are fricatives or approximants).

Manner of articulation was the focus of the methodological study reported in this chapter and the production studies in Chapter 4 and Chapter 5 since it is the most prominent differing feature between /d/ and /ð/, and /b/ and /v/[1] . The goal of the thesis is to check whether Catalan speakers with an advanced level of English produce and perceive English /d/ and /ð/, authentically, in absolute initial and intervocalic positions.

In this chapter I describe the method used in the first production experiment (and the first experiment reported in Chapter 5) and evaluate the consistency between the transcriptions by two transcribers in analysing the

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[1] This chapter deals with the production not only of /d/ and /ð/, but also of /b/ and /v/ because the initial study involved these two English contrasts. Keeping both contrasts in this methodological chapter allows us to generalise the findings to a wider range of sounds.

speech production by L2 speakers. The productions of English /b/, /v/, /d/ and /ð/ by 20 Catalan speakers were classified by 2 human transcribers.

3.1. Purpose of the experiment on production of monomorphemic words

As the present thesis aims at examining the accuracy in production of English /d/ and /ð/ by Catalan learners of English, I designed some materials containing the target English contrast in absolute initial and intervocalic positions for the subjects in the study to read. Ideally, the subjects' spontaneous rather than their read speech should be examined. The problem with spontaneous data for a study on /d/ and /ð/ is the scarce number of words containing the fricative /ð/ in intervocalic position. Their occurrence is likely to be low in spontaneous speech. Besides, words with absolute initial /ð/ are high-frequency words (i.e. definite articles, personal pronouns, demonstrative pronouns), which could create an artefact in the findings.

3.2. General strategy for materials design

Before collecting the data for this study, the materials were piloted on a set of subjects similar to those used in the final study.

In the pilot study for the production test we tried to elicit different kinds of speech in terms of formality. We wanted to check whether speakers monitored their speech more in informal than in formal styles. According to Krashen's (1981) Monitor Theory, there is a dichotomy between learning and acquisition. Learning involves a conscious process when exposed to the rules of a language, whereas acquisition is the unconscious adding of the target

language's well-formed structures or a 'feel' for the language. When language learners speak the target language, they make use of their learnt knowledge and acquired knowledge to different extents. In casual speech, learners are said to make use only of their acquired knowledge. However, the attention to their speech is higher in more formal situations. In these formal situations they use their learnt knowledge rather than their acquired knowledge and their focus on form is higher, generally. The attention learners pay to their speech is what Krashen calls monitoring. Due to the difference in attention to speech, we included an initial task that was a modified version of the Map Task.

Since the production of speakers could be affected by the formality of the task in which they are engaged, different tasks were carried out in order to elicit the production data for this experiment. Labov's claim that "there are no single style speakers" (as cited in Ellis, 1994) makes reference to L1 speakers. However, several L2 researchers (Tarone, 1982; Ellis, 1994) have analysed the variability in the speech of L2 learners. L2 learners seem to have a continuum of styles and they use one or the other depending on the formality of the activity in which they are engaged. Speakers are supposed to pay less attention to their own speech when they are engaged in informal conversation than in formal contexts. This monitoring is responsible for the use of one style or the other. When speakers are really aware of their speech, they tend to use more target-like forms than when their attention to speech is low (e.g. in tasks eliciting informal speech).

A previous study on the English speech of native Catalan speakers (Cebrián, 1997) indicated that some kinds of activities are better than others in eliciting different speech styles. Following this study, a series of materials was designed for the production test: maps for an activity based on the Map task (Brown, Anderson, Shillcock & Yule, 1984; Anderson et al. 1991), a list of words and a list of minimal pairs.

In the first task we aimed at eliciting spontaneous speech style. It was elicited in an activity developed from the Map Task (Brown et. al., 1984; Anderson et al., 1991). This task was chosen because it is communicative in nature and the speech it generates is spontaneous because speakers really focus on conveying a message and do not pay much attention to their speech. In order to carry out the task:

> "Each of the two participants has a map that the other one cannot see, but both collaborate to reproduce on one of the maps a route already printed on the other…. Although the participant with the pre-printed route is designated the Instruction Giver, and the other the Instruction Follower, no restrictions are placed on what either can say." (Anderson et al., 1991, p. 352)

An important reason for picking this task was that, as Anderson et al. (1991) suggest, the names of the landmarks in the map can be modified and, therefore, designed to control phonological variables. The original maps used in the HCRC corpus were altered according to our goal. In this case, subjects acted as Instruction givers whereas the experimenter played the role of the Instruction follower. Subjects had a map in which they had a route whereas the experimenter had the same map with no route and with some landmarks missing. The landmarks in the map for this adaptation were some existing and some invented place names containing the different consonants under study in different utterance positions. Subjects were given the following written instructions at the beginning of the activity: "You have a map with a route marked on it. Your partner has no route on her map. The goal of this task is to reproduce your route on your partner's map. The maps are not identical. Give your partner instructions to go from the starting point to the finishing point in your map in English." The major problem was making up names that contained the voiced dental approximant in them because the grapheme <th> stands for both the voiced and the voiceless dental fricatives.

In order to sort this out, frequent words containing the voiced fricative were chosen and other words were added to them, either at their beginning or at their end, to make them sound like place names. Some of the resulting place names are Thatsfield, Thenford and Keyworthy. Apart from the data elicited from the map task, subjects also read a list of words and a list of minimal-pairs. Our pilot study determined that there was no significant difference in production accuracy between the words elicited in the list and in the minimal pairs. The only significant difference was between the spontaneous speech style (i.e. the data elicited in the map task) and both the word list and minimal pairs reading styles. However, these results are affected by the realisation of the <th> grapheme in English. The grapheme <th> could be pronounced as either [ð] or [θ] in words learners have never come across before. Thus, the data in spontaneous speech showed a clear preference towards [θ] in production when subjects faced these new words. In our data analysis for the whole study we discarded all the [θ] productions of target [ð], as that did not show a difference in manner of articulation of our target /ð/ items, but a difference in voicing. Therefore, the spontaneous speech data set was discarded. As the analysis of the different reading styles exhibited no significant difference, the data in the word list and the minimal pairs were pooled together and the whole corpus was analysed as data elicited in a reading task.

3.3. General description of subjects

The subjects examined here were bilingual speakers in Catalan and Spanish who, at the moment they were interviewed, were about to finish their advanced English level courses in language schools in Barcelona and Palma. This is the profile of students chosen in order to find out whether after being exposed to English for quite a long time (due to their advanced

level of knowledge of this language) L2 speakers acquire English /d/ and /ð/ without explicit training. In the questionnaire they answered at the end of the recording session, they were asked whether they had taken any course on English phonetics and whether they had explicitly been taught the contrast under study.

3.4. Method

3.4.1. Data analysis

When thinking about the analysis of the production data we would obtain, we considered the different methods of analysis available. Traditionally, L2 production data has been examined by using acoustic analysis or auditory analysis by native speakers of the target language. For some sounds such as /d/ and /ð/, the acoustic measurements are not ideal due to their acoustic similarity. Zue (1988) describes the voiced interdental fricative's spectrogram as one that appears stop-like because of an apparent voiced closure followed by what looks like a burst, even in cases where it is clearly heard as an instance of a voiced fricative. Therefore, if we want to discern between acoustically similar sounds we should analyse the data auditorily. We want to check how this L2 speech will be perceived by native speakers of the target language. Although in many studies the experimenters analyse the data auditorily themselves, the experimenter in the present study was not a native speaker of the target language under study (i.e. English). Hence, some phonetically trained English speakers were selected for the analysis of the data. [2]

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[2] The data included in this chapter were also analysed by a speech recogniser. A summary of the findings in comparing the results of the speech recogniser with those of the transcribers can be found in Appendix B.

3.4.2. Materials

The production corpus (i.e. the data presented in Chapter 4 and partially in Chapter 5) contains words elicited in a production test. The production data of the Catalan speakers were collected by means of a word list, minimal pairs and a fill-in-the-blank task. The whole corpus contains 2400 items. However, for this methodological study we decided to use 10% of the items, randomly selected from the corpus, in order to compare the agreement in transcription by the two transcribers. The following chapter and the first experiment in Chapter 5 examine the data in the rest of the whole corpus.

A fill-in-the-blanks task was devised for subjects to produce derived words that they created when given a monomorphemic word in English with the target stops under study in final position. The derived word should complete the sentences with the blank, and after the derivation the target underlying English segment was in intervocalic position. This task is fully described in Chapter 5 because of the relevance to discussion in the chapter.

A list of words containing the target phones in initial and intervocalic position was designed. In order to decide which words to choose, the CELEX database, devised by Baayen, Piepenbrock & Gulikers (1995, 1996)[3], was used with a user interface devised by Cedric MacMartin. CELEX is a corpus of English, Dutch and German lexicons which provides a detailed account of the parsing and pronunciation or English, Dutch and German words. The frequency of occurrence of the words with our target phones in the desired position was checked in CELEX and those with higher frequency values (i.e. those words with a higher Coblog value) were chosen. The words were

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[2] This is the reference for the CD-ROMS. For more information on how to access CELEX, see http://www.kun.nl/celex/subsecs/section_acc.html

presented to subjects individually on notecards, in order to elicit pauses between words, and to provide a distraction from the goals of the task.

The last set of stimuli consisted of minimal pairs (or near minimal pairs when complete minimal pairs did not exist), containing /d/ and /ð/, and /b/ and /v/ in initial and intervocalic position. Examples of these (near) minimal pairs are *day-they*, *blather-bladder*, *ban-van* and *sober-over*. Both members of a minimal pair were presented to readers on a single card, and were to be read consecutively. The order in which the target segments was presented (e.g., first the word with target /d/ and then the word with target /ð/, and the other way round) was randomised.

The recording equipment was the same as in the perception study (a Sony TCD-D8 DAT recorder) plus a Shure 16A microphone in a tripod stand. The microphone was placed 20 centimetres away from the mouth of the speaker.

3.4.3. Subjects

The Catalan subjects for this test were the same as those in the perception test: ten bilingual speakers of Central Catalan and Spanish (9 females, 1 male) and ten bilingual speakers of Majorcan Catalan and Spanish (9 females, 1 male). The Central Catalan (mean age=33, range 20 to 58 years) and the Majorcan Catalan subjects (mean age=25, range 18 to 32 years) studied English at a language school in Barcelona and in Palma, respectively. They were about to finish their Certificate of Advanced English (CAE) courses. All were adults who reported having normal hearing and were paid for their participation. The requirements for eligibility were the same as those for the perception experiment. That is, they should have not lived in an English speaking country for more than 8 weeks and they should have never taken a course on phonetics. The reason behind this was for the analysis to

describe the speech of average Catalan students who generally learn their English in language schools at their home country and have no specific training in phonetics.

3.4.4. Procedure for data elicitation

Subjects carried out four tasks in a single session. The order of tasks was one of increasing formality and was kept constant across participants. A fill-in-the-blanks task (explained in the Chapter 5 because it was part of the polymorphemic words' production experiment) was the first task. Then, the reading of the list of words containing the target phones in initial and intervocalic position followed. Then, the perception test described in Chapter 2 was run. In this activity, the goal of the project was quite clear because subjects were explicitly told to choose between /b/ and /v/, and /d/ and /ð/, depending on the item they heard in each case. Finally, the Catalan speakers were asked to read the list of minimal pairs, in which the target contrast was clearly shown. Since subjects at this stage were very aware of the aim of this project, reading minimal pairs was considered to be the most formal task. Informants were thought to be monitoring their speech to a great extent in such an activity. The two production tasks (i.e. word list and minimal pairs) had already been used in Cortés (1999a, 1999b, 2000) and in the pilot for this test. No significant difference was found in the production of words elicited in word lists and minimal pairs. Due to this fact, we decided to analyse all the words elicited (without the words elicited in the fill-in-the-blanks task) as a single body of read data in the experiment described in Chapter 4, where task is no independent variable.

3.4.5. Transcriptions

The segments of interest in the data set were analysed by two phonetically trained native English speakers. The data was made available in a data CD-ROM in which every sound file (i.e. a word with a segment to be transcribed) was played after their identification number. For the purpose of the thesis, each transcriber listened to one half of the entire corpus (i.e. 1200 items each transcriber) plus a fifth (i.e. 240) of the remaining half. This meant that 10% (i.e. 240 items) of the corpus was analysed by both transcribers – the portion of the data examined in this chapter which was also run through a speech recogniser. The rest of the data elicited in the first production test was divided in two blocks and each one was auditorily analysed by a phonetically trained native English speaker (MC and ZB). They were asked to identify the segment they heard in initial or intervocalic position (depending on the token) as either /d/ or /ð/ and /b/ or /v/, or provide their own transcription if they thought the sound corresponded to none. Transcriptions could be problematic but it is one of the available methods of analysis where we can check whether target phones are recognised as such by native speakers. As Flege, Bohn and Jang (1997) state, "transcription practices and symbolization may vary across languages, and vowels transcribed using the same IPA symbol (e.g. the /u/s of Korean and English (Yang, 1996)) may differ systematically" (p. 441). This is an objection many other researchers share (Port & Leary, 2005). However, their claim is about using the IPA phonetic symbols to consider some languages' sounds as the same or different, even if the IPA symbol coincides but there is some phonetic difference in their realisation. This could affect the judgement of Catalan speakers about the pronunciation of Catalan speakers of English. That is why we used native speakers of English, who had been phonetically trained in the Linguistics department at the University of Edinburgh. In short,

we checked how the production of stops and non-stops by Catalan speakers of English are perceived in terms of British English standards.

For each item, they did not know what the target word was but were asked to indicate whether a phone in a specific position in the item was /d/ or /ð/, and /b/ or /v/, depending on the item. If they did not think the segment fit either member in the choice, they provided us with their own phonetic transcription for that sound.

3.5. Results and discussion

Table 3.1. shows the percentage of agreement among the two human transcribers, MC and ZB, and the speech recogniser.

Table 3.1. Total agreement ratio and % agreement between analysers.

	MC vs. ZB
Total agreement ratio	208/240 items
% of agreement	86.67% agreement

Chi-square tests were run on the total numbers of agreements between analysers. The agreement was highly significant between MC and ZB (χ^2= 129.067; df= 1; p< .001) .

In Table 3.2., we can observe the rate of segments classified as being targetlike.

Table 3.2. Ratios and percentages of correct production in separate analyses by analysers[4].

	MC	ZB
Initial /b/	27/27= 100%	27/27= 100%
Intervocalic /b/	20/33= 60.60%	24/33= 72.72%
Initial /v/	15/27= 55.55%	19/27= 70.37%
Intervocalic /v/	40/45= 88.88%	40/45= 88.88%
Initial /d/	25/29= 86.2%	25/29= 86.2%
Intervocalic /d/	10/25= 40%	12/25= 48%
Initial /ð/	9/23= 39.13%	16/23= 69.56%
Intervocalic /ð/	29/31= 93.54%	29/31= 93.54%

In some cases, the transcriptions of the same tokens by the two transcribers did not coincide. In order to check whether the transcriptions are comparable in those cases and whether we can use their transcriptions reliably, chi-square tests were run on the transcriptions by MC and ZB when they did not coincide completely.

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[4] Shaded cells in the same row indicate identical figures by different analysers.

Table 3.3. Results of chi-square tests run on the analyses for a given phone in a given position by different analysers.

	Chi-square results MC vs. ZB
Interv. /b/	χ^2= 1.091; df= 1; p= n.s.
Initial /v/	χ^2= 1.271; df= 1; p= n.s.
Interv. /d/	χ^2= .325; df= 1; p= n.s.
Initial /ð/	χ^2= 4.293; df= 1; p= .038

The most important finding in Table 3.3. is that most of the differences between MC's with ZB's transcriptions do not reach significance. Only the transcriptions by MC and ZB for initial /ð/ seem to differ. It is interesting to notice that this is precisely the context where the least number of target items were drawn from the total corpus. It is likely that the reason behind the comparison of transcriptions reaching significance is that the sample of items is small. A larger sample might not allow for significance to arise. If the transcriptions between MC and ZB for the whole corpus show very different results, this issue will be dealt with in the discussion of the production experiments. For now, we can conclude that, since there is no major significant difference between the transcriptions by the two English transcribers, they will proceed on transcribing half of the whole corpus each.

3.6. Conclusion

The results show that the transcriptions by the two transcribers do not differ significantly overall. Hence, the whole corpus of data in chapter 4 was analysed by MC and ZB. However, the data reported in chapter 5 were only transcribed by ZB because that was done at a later stage, when MC was not available, and it was a smaller corpus.

CHAPTER 4

PRODUCTION EXPERIMENT 1: MONOMORPHEMIC WORDS

4.1. Introduction

In this chapter, we test Catalan learners of English to determine whether their production performance can be predicted on the basis of their perception results. Since context does not appear to affect perception of the /d/-/ð/ contrast, as shown in Chapter 2, any observed production errors may be attributable to transfer from the L1 system during the production process itself. As discussed in the following sections, comparisons of production accuracy in intervocalic vs. initial contexts will reveal the types of representations and processes that are transferred from L1 to L2 during L2 speech production.

4.2. Hypotheses

Five different hypotheses were formulated that illustrate the different possible ways L1 underlying representations and underlying-to-surface mappings might transfer to the L2 production system. For all these hypotheses, we assume that L1 segments (either underlying or surface segments) are transferred onto the L2 system as underlying L2 segments. The hypotheses we formulated take into account the L1 level (i.e. underlying or

surface level) from which segments are transferred to the L2 inventory of contrastive segments. Segments in L1 can be either underlying or surface.

These five hypotheses take all the possibilities of the levels where the L1 segment is (i.e. underlying and surface) and the mappings (i.e. L1 underlying-to-surface mapping and mapping to a default) onto L2 categories which are contrastive (i.e. L2 underlying segments.) An abstract formulation of the hypotheses is followed by a description of what it means:

- **Hypothesis 1 (or transfer of L1 Underlying Segment as Default Surface Segment):** An L2 target contrastive segment /x/ is produced as [x] if [x] is the surface realisation of /x/ in L1 with the widest distribution. That is, L2 speakers transfer their L1 inventory of underlying segments onto L2, and assume a one-to-one mapping from L2 underlying to surface segments;

- **Hypothesis 2 (or transfer of L1 Underlying Segment as any L1 Surface Segment):** An L2 target contrastive segment /x/ is produced as [x] or [y] if [x] is a surface segment because the L1 underlying segment /x/contains these two surface realisations. In this case, L2 speakers transfer their L1 inventory of underlying segments onto L2, and all the surface realisations included in the underlying segment but the output is unpredictable because any surface realisations can be used at any time;

- **Hypothesis 3 (or transfer of L1 Surface Segments):** An L2 target contrastive segment /x/ is produced as [x] if [x] is a surface realisation of some underlying segment in L1. This means that L2 speakers transfer their L1 surface realisations to the L2 inventory of underlying segments;

- **Hypothesis 4 (or transfer of L1 Underlying Segment as Default Surface Segment with L1 Underlying-to-Surface Mapping):** An L2 target contrastive segment /x/ is produced as [x] if [x] is the surface realisation of /x/ in L1 with the widest distribution and if [x] occurs in the context in which /x/ surfaces as [x] in L1. That is, L2 speakers transfer L1 underlying segments and only the default surface segment is transferred with the mapping from underlying to surface level in L1; or

- **Hypothesis 5 (or transfer of L1 Underlying Segment as any L1 Surface Segment with L1 Underlying-to-Surface Mapping):** An L2 target contrastive segment /x/ is produced as [x] if [x] occurs in the context in which /x/ appears as [x] in L1. Namely, L2 speakers transfer their L1 underlying segments to L2 and the mapping from underlying-to-surface segments in L1 is also transferred.

This project attempts to advance our understanding of L2 transfer by looking at the production of /d/ and /ð/ by Catalan learners of English.

4.3. Predictions from hypotheses for monomorphemic words

In order to test our hypotheses, we used Catalan speakers of English because their L1 and L2 have different contrastive underlying segments and different realisations of the same segments in the same contexts. This will allow us to discern whether it is surface or underlying segments that are

transferred to L2 inventories. In Catalan, the [d̪] and [ð̪] phones occur only in restricted positions. The stop occurs in absolute initial position (among others) and the approximant in intervocalic (or postcontinuant) position. On the other hand, in English both the voiced alveolar stop and the voiced dental fricative occur in absolute initial and intervocalic position. The present study aims at finding out what the mapping between speaker's L1 and L2 segments is like when they pronounce these L2 contrastive segments. We focus on whether the production/perception of the target segments is that of a stop or a non-stop[1]. The following section describes each of our five hypotheses and the predictions about Catalan speakers' pronunciation of English /d/ and /ð/.

Our hypotheses assume that the level at which L1 segments that are transferred are plays a role in the L2 output we obtain in the production of L2 learners' speech. Our hypotheses will allow us to test whether L1 underlying segments are mapped onto L2 contrastive segments and/or whether the L1 underlying-to-surface mapping transfers onto the L2 system.

4.3.1. Predictions for /d/ and /ð/ production

The first hypothesis assumes an L1 inventory transfer and a mapping to a default realisation, as seen below:

---

[1] We will use the fricative symbol when we refer to [- stop] manner of articulation, for the sake of brevity.

L1	L2
/underlying segment/ $\longrightarrow$	/underlying segment/
↓	↓
[surface segment]	[L1 underlying segment as default surface segment] in any position

Prediction

Cat (L1)	E (L2)	Cat (L1)	E (L2)
/d̪/ $\longrightarrow$	/d̪/ /ð/	/d̪/ $\longrightarrow$	/d̪/ /ð/
↓	↓ ↓?	↓	↓ ↓ ?
[d̪]	[d̪] ?	[ð]	[d̪] ?

Initial position   Intervocalic position

e.g. <u>d</u>ay > *<u>th</u>ey*   bo<u>d</u>y   > *ei<u>th</u>er*

   <u>d</u>ay ≈ bo<u>d</u>y   *<u>th</u>ey   ≈ ei<u>th</u>er*
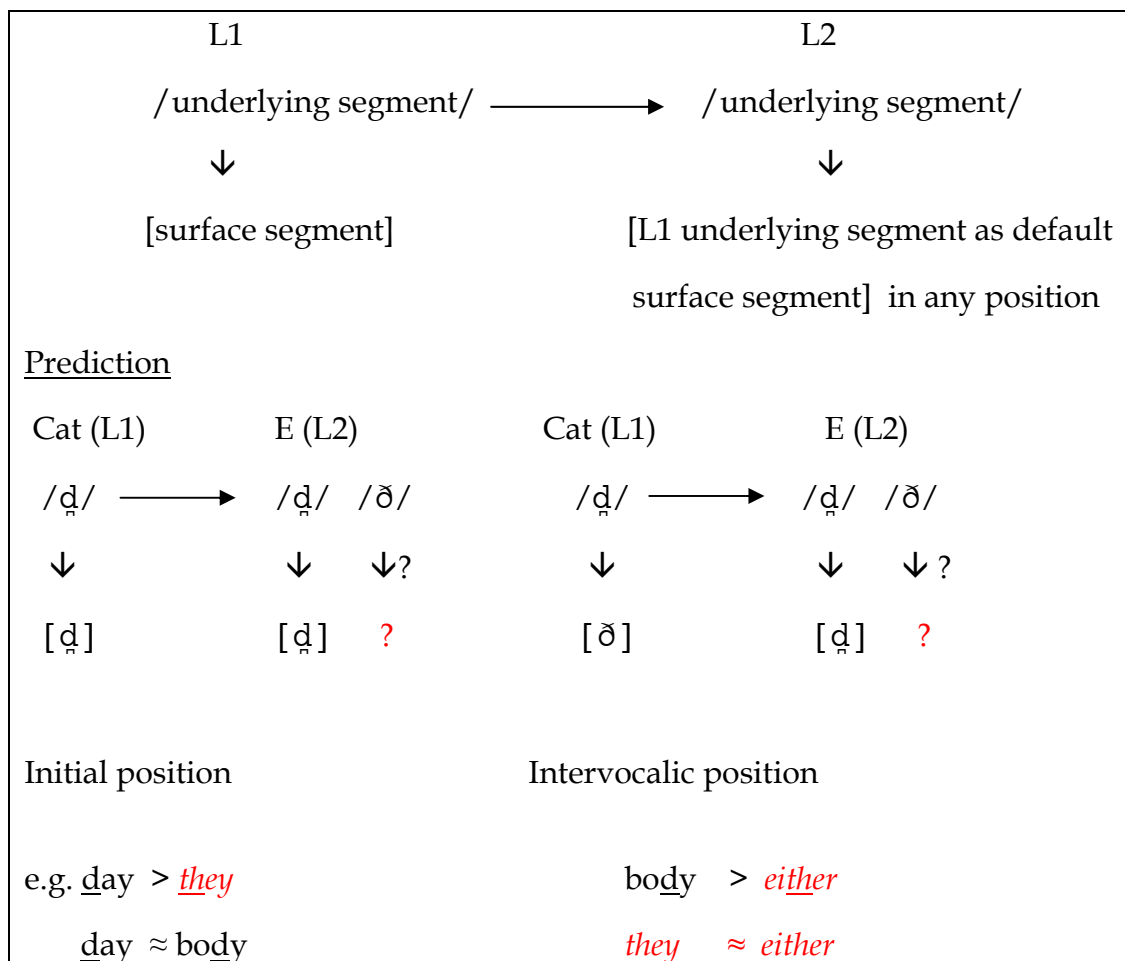
Fig. 4.1. Hypothesis 1 and predictions. [2]

Hypothesis 1 (or transfer of L1 Underlying Segment as Default Surface Segment) predicts that /d/[3] will be correctly produced in any position because it exists as an underlying segment in Catalan and will, consequently,

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[2] Horizontal arrows stand for the transfer, vertical arrows stand for the mapping from phonemes to allophones and question marks indicate problematic cases because of lack of category in L1 to be transferred to L2. Examples in the format X>Y read "the production of X is more target-like than that of Y." Examples are in italics if their production is not very target-like. Examples in the format X<Y read "the production of X is less target-like than that of Y." X≈Y reads "the production of X and Y is similar in terms of how they approach target-like pronunciations."

[3] Although figures state that the representation taken from Catalan is /d̪/, in text we use the English symbol because that is assumed to be the interpretation from the point of view of an English speaker, as that of the transcribers in the experiment.

be transferred to the English inventory of contrastive segments and a mapping to a default realisation will follow. On the other hand, the voiced dental fricative will be less accurately produced in any position because, as it does not exist at the underlying level in Catalan, it cannot be transferred to the English inventory.

As an illustration, we could say that Catalan learners of English will only transfer their L1 underlying segment (i.e. /d̪/)[4]. If they transfer it, then their pronunciation of words like '[d]ay' and 'bo[d]y' will surface with a [d]. Since they have the underlying segment /d̪/ in their L1, their stop-like production of target English [d] will be approximately accurate – as it corresponds to the L1 surface segment with the least restricted distribution in L1 – in any position in L2. The production of words containing the target contrastive segment /ð/ (e.g. '[ð]ey', 'ei[ð]er') will be problematic because, even though the underlying segment /d̪/ which is transferred onto L2 contains both Catalan [d̪] and [ð̪], /d̪/ will only surface as the L1 surface realisation with the least restricted distribution (i.e. [d̪]) but never as [ð̪] in L2.

Hypothesis 2 (or transfer of L1 Underlying Segment as any L1 Surface Segment) assumes that the underlying segment in L1 can include all L1 surface realisations of this category. After the L1 underlying segment transfers, any surface segment could be chosen at random as its realisation. This means that the behaviour would be totally unpredictable.

---

[4] We will use absolute initial position and intervocalic position (i.e. an example of postcontinuant context) realisations in these examples and in our study throughout the thesis.

```
┌─────────────────────────────────────────────────────────────────────┐
│            L1                              L2                          │
│                                                                       │
│   /underlying segment/  ──────────►  /underlying segment/             │
│            ↓                               ↓                          │
│                                                                       │
│     [surface segment]          [L1 underlying segment as any of       │
│                                                                       │
│                                   its L1 surface realisations]        │
│                                                                       │
│                                                                       │
│ Prediction                                                            │
│                                                                       │
│ Unpredictable output                                                  │
└─────────────────────────────────────────────────────────────────────┘
```
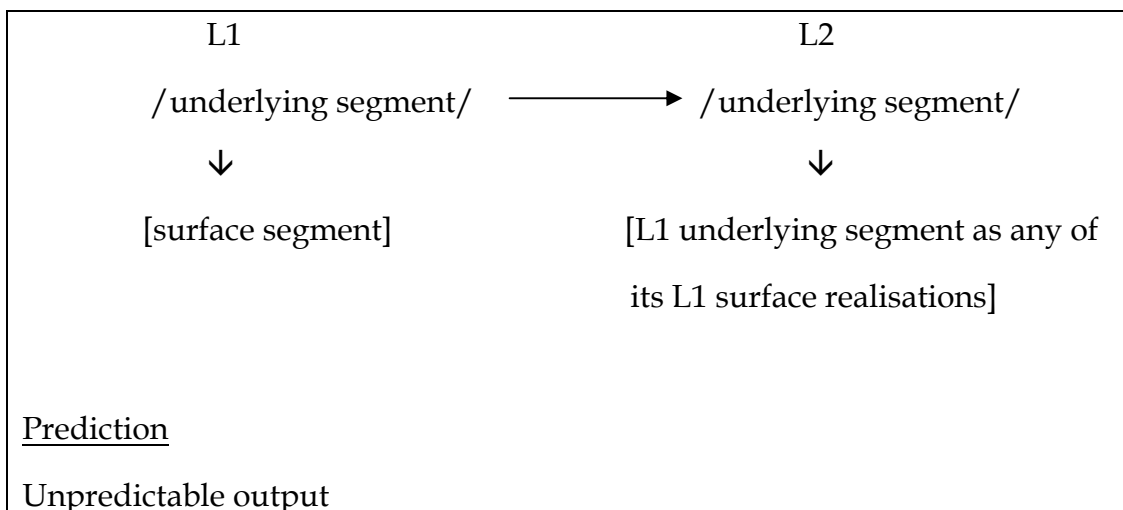
Fig. 4.2. Hypothesis 2 and predictions. Symbols as explained in footnote 2.

If this was the case, then the L2 inventory of underlying segments would include the L1 underlying segment which would surface as any of the L1 surface realisations in all contexts. If they transfer this sound, then their pronunciation of words like '[d]ay' and 'bo[d]y' will contain either of the L1 surface realisations. For target English /d/ they will be producing any of the L1 surface segments which are contained in the Catalan /d̦/ underlying segment. The production of words containing the target underlying segment /ð/ (e.g. '[ð]ey', 'ei[ð]er') will also be unpredictable because the L1 underlying segment transferred contains both [d̦] and [ð̦], and any of the two will surface anytime English /d/ or /ð/ are intended.

Hypothesis 3 (or transfer of L1 Surface Segments) states that the L1 surface segments are is transferred to the L2 segmental inventory and a mapping to a default phonetic realisation follows (as in Fig. 4.4.).

```
          L1                              L2
  /underlying segment/          /underlying segment/
          ↓                              ↓
    [surface segment]          [surface segment] in any position


Prediction

 Cat (L1)        E (L2)          Cat (L1)        E (L2)

  /d̪/            /d̪/             /d̪/            /ð̪/

   ↓            ↙ ↘               ↓             ↙ ↘

  [d̪]        [d̪] [d̪]           [ð̪]         [ð̪] [ð̪]

           Initial Intervocalic          Initial Intervocalic

 e.g.     day ≈ body                  they ≈ either

          day ≈ they                  body ≈ either
```
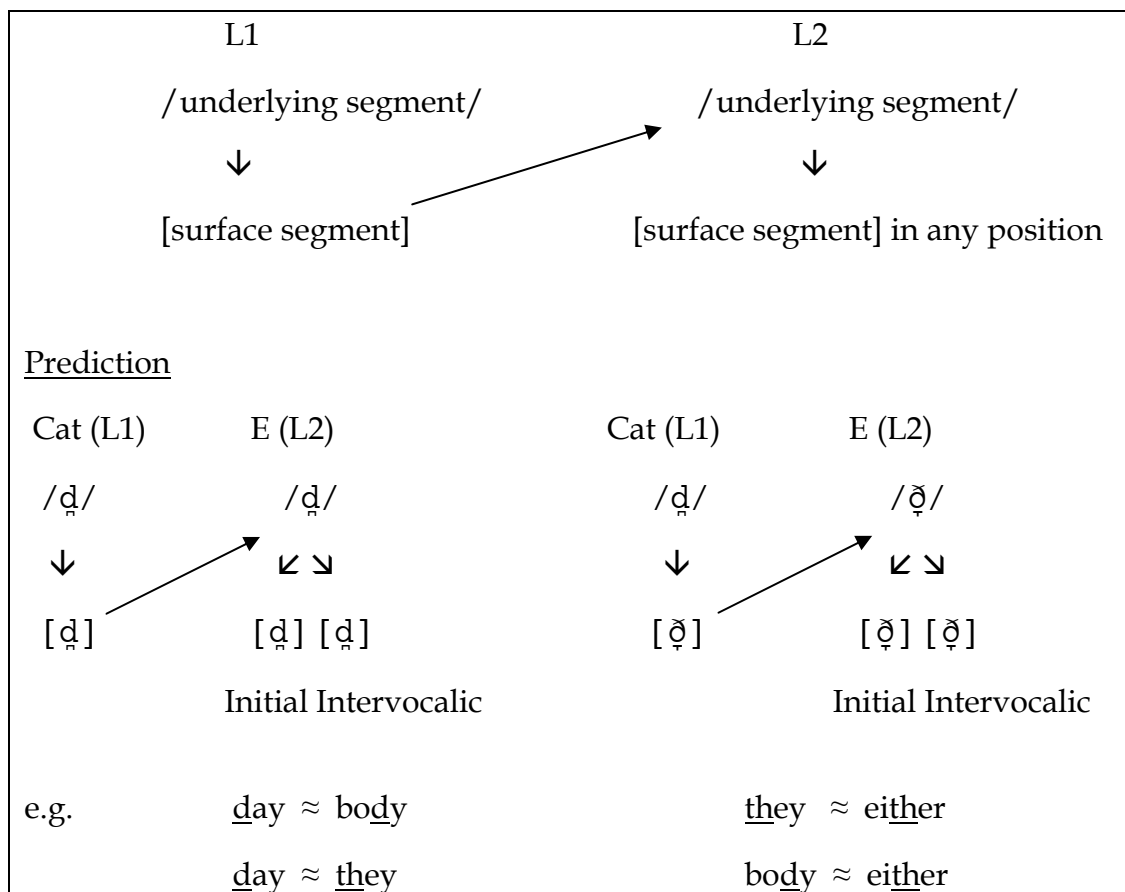
Fig. 4.3. Hypothesis 3 and predictions. Symbols as explained in footnote 2.

Hypothesis 3 predicts that the production of /d/ and /ð/ in any position will be accurate because both segments are surface realisations in L1 and will be transferred to the L2 inventory of underlying segments. This transfer will be followed by a mapping to a default realisation. Such a possibility (i.e. transfer of L1 Surface Segments) predicts that Catalan learners of English will transfer their L1 surface segments (i.e. [d̪] and [ð̪]) to their L2 sound system and will pronounce them as target stops and fricatives correspondingly, regardless of the context they occur in. In this way, they will pronounce both '[d]ay' and 'bo[d]y' with stops, and they will also produce '[ð]ey' and 'ei[ð]er' with non-stops.

Hypothesis 4 (or transfer of L1 Underlying Segment as Default Surface Segment with L1 Underlying-to-Surface Mapping) states that both the L1 underlying segments and the L1 underlying-to-surface mapping are transferred. This is indicated by the horizontal arrows in Fig. 4.5.

L1		L2
/underlying segment/	⟶	/underlying segment/
↓	⟶	↓
[surface segment]		[surface segment]

Prediction

Initial position   Intervocalic position

Cat (L1)   E (L2)   Cat (L1)   E (L2)

/d̪/ ⟶ /d̪/ /ð/   /d̪/ ⟶/d̪/ /ð/

↓ ⟶ ↓ ↓?   ↓ ⟶ ↓ ↓?

[d̪]   [d̪]   ?   [ð]   [ð] ?

e.g. *day* > *they*   *body* ≈ *either*
      day > *body*   *they* ≈ *either*
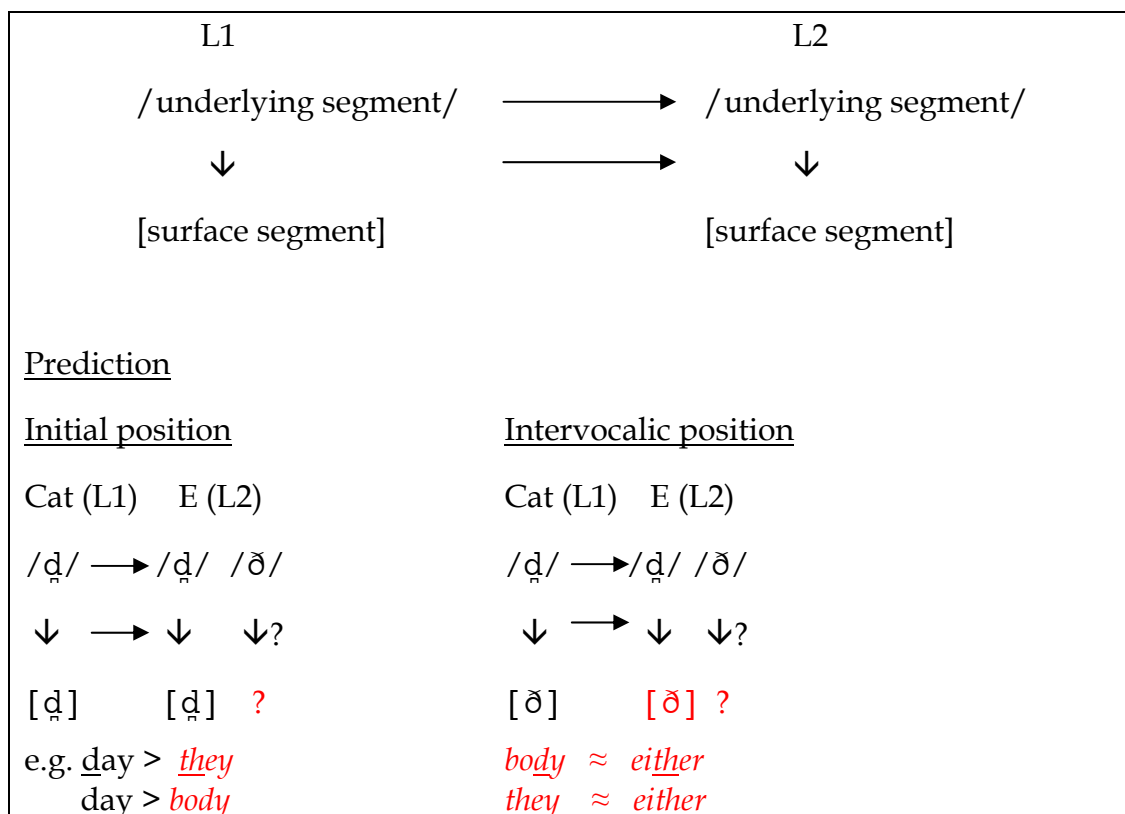
Fig. 4.4. Hypothesis 4 and predictions. Symbols as explained in footnote 2.

Hypothesis 4 (or transfer of L1 Underlying Segment as Default Surface Segment with L1 Underlying-to-Surface Mapping) states that only L1 underlying segments are transferred to L2. Therefore, /d/ is transferred. According to this hypothesis, the mapping from underlying-to-surface forms is also transferred. Thus, /d/ is predicted to be correctly produced in an absolute initial position but not in an intervocalic position.

This hypothesis predicts that Catalan learners of English will transfer

the L1 underlying (i.e. /d̪/) but only to the contexts in which this the surface realisation with the least restricted distribution (i.e. [d̪]) occurs in L1 (i.e. non-intervocalic position). Therefore, they will pronounce the [d] in '[d]ay' as a stop but not in 'bo[d]y'. Since their underlying segment /d̪/ which is transferred to L2 is thought of only being related to its L1 default realisation [d̪], the production of target English /ð/ (in any position in the word) will not be accurate.

Hypothesis 5 combines the idea of transferring the L1 underlying segment containing all its surface realisations with the fact that such surface segments will only surface in the positions in which they surface in L1.

L1	L2
/underlying segment/ ⟶	/underlying segment/
↓	↓
[surface segment]	[L1 surface segments in their L1 contexts only]

Prediction

Initial position   Intervocalic position

Cat (L1)   E (L2)   Cat (L1)   E (L2)

[d̪] ⟶ # [d̪]   V [ð̪] V ⟶ V [ð̪] V

e.g. day > *they*   *body* < ei*th*er

day > bo*dy*   *they* < ei*th*er

Fig. 4.5. Hypothesis 5 and predictions. Symbols as explained in footnote 2.

The last hypothesis predicts that the output conditions of Catalan will be transferred to the surface forms of English spoken by Catalan speakers, that is, only the forms that surface in L1 will also surface as such in L2. This means that /d/ will be better produced in absolute initial position than in intervocalic position, whereas /ð/ will be more accurately produced in intervocalic than in initial position. That is, they will only be accurately produced in the contexts where these sounds occur in Catalan.

According to this hypothesis, Catalan speakers of English will transfer their L1 underlying segment /d̪/ which contains its two allophones (i.e. [d̪] and [ð̪]) to their L2 but only pronounce them as a stop and a non-stop in the contexts where these surface segments occur in Catalan. Therefore, they will pronounce '[d]ay' with a stop but not 'bo[d]y'. This is a reproduction of their Catalan production pattern. They will also reproduce their L1 output when pronouncing a word like '[ð]ey' with an initial stop but will produce a word like 'ei[ð]er' with an intervocalic approximant, since this is the only possible production in that position in Catalan.

4.4. Analysis

The data elicited in this production test was divided in two blocks and each block was auditorily analysed by a phonetically trained native English speaker (MC and ZB). They analysed 50% of the corpus each, plus a 10% which was analysed by both of them (i.e. the data analysed in the methodological comparison in Chapter 3). The sound files for the target

items were placed in a script which randomized them, put each word after an auditorily presented number and before a pause for the transcribers to do the transcriptions. Transcribers were asked to identify the segment they heard in initial or intervocalic position (depending on the token) as either /d/ or /ð/, or provide their own transcription if they thought the sound corresponded to none of them. They were not given the spelling of the target word for each item and were only asked to transcribe the phone in initial or intervocalic (or post [ɹ]) position in each sound file, not the whole word.

Due to the fact that <th> stands for both /ð/ and /θ/ in English, the data where target /ð/ was pronounced as [θ] was eliminated from the corpus. Such a filtering of the data also helped us to get rid of any effect due to Spanish language dominance in any of our subjects, as Spanish has /θ/ as a contrastive segment in its inventory and that could affect the production of English coronals. Producing target /ð/ as [θ] also revealed that learners might not know the word and randomly associated the grapheme <th> with one of the two phonemes it represents in English spelling. As I have stated above, the aim of the thesis was to detect accuracy in manner of articulation, and not voicing as [θ] production for target /ð/ shows.

We should emphasise the fact that our hypotheses make predictions about how a segment will be more or less accurately produced than another segment in the same context or than the same segment in a different context. It is the comparison between different sounds in the same position or the comparison of the same segment in different positions that interests us. Absolute numbers say nothing about the production of segments. In this piece of research, we do not expect categorical but relative results because we assume that transfer is not an all-or-nothing phenomenon but a gradient process. The assumption behind this is that during the learning process, transfer will gradually disappear as the learner is exposed to L2 input and

the differences in production between the L1 system and the target system become clearer to them.

After initial ANOVAs, the five hypotheses outlined in 4.4. were tested using planned comparisons. The initial ANOVAs were two-way repeated measures for /d/ and /ð/. The planned comparisons were one-way within group ANOVAs.

4.5. Results

4.5.1. Results of the auditory analysis

4.5.1.1. Pooled results for the production of /d/ and /ð/

The output of the transcribers' work was filtered in a way such that for target /d/ items, any transcription output as [d], [d̪] and intervocalic [ɾ] was considered a good production of /d/. We considered all these items to be good productions of target /d/ because all of them involve complete closure, although brief in the case of the tap. For target /ð/ items, tokens produced as [θ] were discarded. Results of the analysis can be observed in the table below.

Table 4.1. Percentage and numbers of accurately produced /d/ and /ð/, analysed by MC.

	POSITION	
	Initial	Intervocalic
/d/ produced as /d/	85.52% 119/139 s.d. 13.64	45.86% 41/91 s.d. 25.19
/ð/ produced as /ð/	54.85% 53/97 s.d. 31.39	86.03% 68/78 s.d. 24.57

Table 4.2. Percentage and numbers of accurately produced /d/ and /ð/, analysed by ZB.

	POSITION	
	Initial	Intervocalic
/d/ produced as /d/	92.47% 126/136 s.d. 14.29	61.1% 66/108 s.d. 24.64
/ð/ produced as /ð/	55.94% 71/128 s.d. 33.08	94.83% 91/96 s.d. 9.38

Production of /d̪/ and /ð/ analysed by MC

Production of /d̪/ and /ð/ analysed by ZB
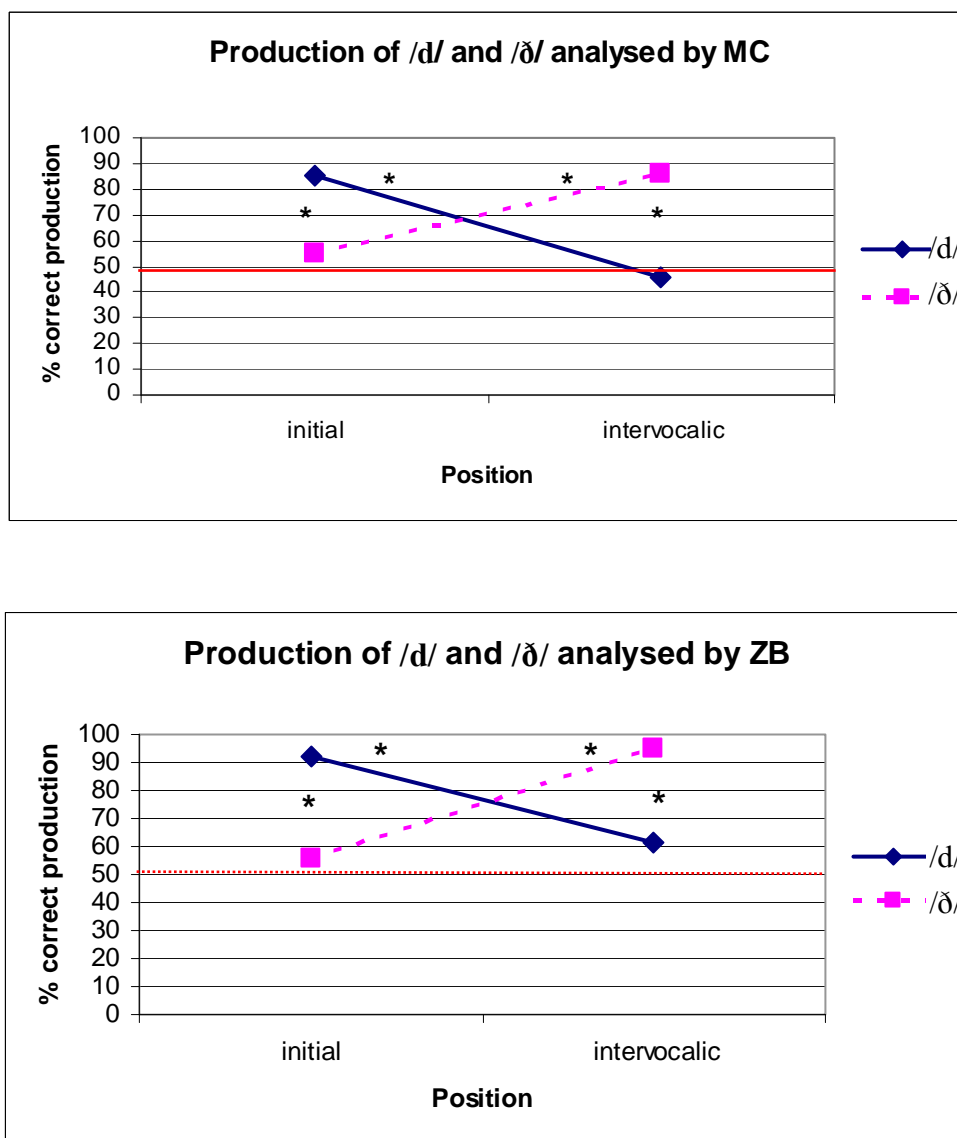
Figure 4.6. Total correct production of /d̪/ and /ð/ by Catalan speakers, as analysed by MC (top panel) and ZB (bottom panel).

Figure 4.6. shows the results of /d̪/ and /ð/ production by Catalan speakers. There is a clear interaction between Contrastive L2 Segment and Position.

Two separate two-way repeated measures ANOVA tests were run on the data analysed by both transcribers. These statistical tests revealed a significant Contrastive L2 Segment x Position interaction: MC: [$F_{(1, 19)}$ =

45.236; p < .001]; ZB: [F (1, 19) = 83.262; p < .001]. Such an interaction means that a difference in production depends on the position of the target English underlying segment.

The two main effects did not reach significance: Contrastive L2 Segment (MC: [F (1, 19) = .562; p = .463]; ZB: [F (1, 19) = .047; p = .830]) and Position (MC: [F (1, 19) = .792; p = .385]; ZB: [F (1, 19) = .591; p = .452].)

Planned comparisons were carried out to test the specific predictions of each of our four hypotheses, namely, comparisons between initial and intervocalic /d/, initial and intervocalic /ð/, initial /d/ and initial /ð/, and intervocalic /d/ and intervocalic /ð/. These comparisons are crucial because their reaching significance or not will let us discern which hypothesis is supported. These are the key comparisons due to the predictions of each hypothesis.

Table 4.3. Planned comparisons on /d/ and /ð/ by transcriber (MC and ZB.)

	MC	ZB
Initial vs. intervocalic /d/	F (1, 19) = 46.321; p < .001*	F (1, 19) = 37.787; p < .001*
Initial vs. intervocalic /ð/	F (1, 19) = 14.547; p = .001*	F (1, 19) = 29.445; p < .001*
Initial /d/ vs. /ð/	F (1, 19) = 12.587; p = .002*	F (1, 19) = 18.006; p < .001*
Intervocalic /d/ vs. /ð/	F (1, 19) = 26.386; p < .001*	F (1, 19) = 29.635; p < .001*

In the analysis by the two transcribers there is no discrepancy because significance was reached in all the planned comparisons displayed in Table 4.3. This confirms the reliability and congruence of the transcriptions provided by the two transcribers.

The results of this analysis show that, for example:

- day > they

/d/ is more accurately produced than /ð/ in initial position

- day > body

/d/ is more accurately produced in initial than in intervocalic position

- bo<u>d</u>y < ei<u>th</u>er

/ð/ is more accurately produced than /d/ in intervocalic position

- <u>the</u>y < ei<u>th</u>er

/ð/ is more accurately produced in intervocalic than in initial position

These are the main differences in the production of our subjects. The results indicate that the production is coherent with the predictions formulated by the hypothesis 5.

4.6. Discussion

The data in our study show that hypothesis 5 is clearly supported.

The production of /d/ in absolute initial position and that of /ð/ in intervocalic position reach ceiling effects. However, the production of intervocalic /d/ is significantly poorer than that of initial /d/ and of intervocalic /ð/. In turn, the production of initial /ð/ is significantly poorer than that of initial /d/ and intervocalic /ð/.

The clear results for /d/ and /ð/ highlight the importance of the L1 output surface conditions for the correct target pronunciation in the L2. L1 sound distribution is crucial for us to be able to predict whether the L2 segments will be correctly produced or not.

Hypothesis 5 highlights the importance of a straightforward L1 to L2 mapping in which the L1 context of occurrence determines when the L2 segments will be correctly produced. However, in the contexts in which the

L2 target segments occur but do not match with the L1 contexts where they do, our advanced Catalan speakers of English do not produce /d/ and /ð/ above chance level, as a group (MC analysis: intervocalic /d/ [t (19) = -.770, n.s.]; initial /ð/ [t (19) = .692, n.s.] – ZB analysis: intervocalic /d/ [t (19) = 1.823, n.s.]; initial /ð/ [t (19) = .804, n.s.]). The overall results suggest that advanced speakers are learning the way L2 segments should be pronounced in different contexts but still their production of /d/ and /ð/ is significantly more accurate in the environments in which L1 and L2 match.

Even though /d/ and /ð/ is a case of allophonic split which is supposed to be one of the most difficult scenarios for L2 learners, our subjects seem to be on their way to an accurate pronunciation of L2 phones, with no explicit phonetic instruction. Therefore, we could suggest that it is possible to approximate a near-native pronunciation of an L2 contrast when L1 only has one underlying segment with context-conditioned surface forms without explicit phonetic training. Learners are able to notice the subtle phonetic differences between the L1 and L2 implying a change in manner of articulation after being exposed to the target language for a considerable amount of time.

An output as the one obtained in this study and predicted by our last hypothesis could also be interpreted as the L1 rules have been transferred onto the L2 words. In this case we observe that the English pronunciation of Catalan speakers shows a possible transfer of the L1 spirantisation rule to the L2 phonological system. In theory, it is very difficult to find a case which will let us discern whether it is the output or the rules leading to that output that are transferred. No matter which of these two possibilities is true, the main finding of our study is that surface segment in specific contexts in L1 are transferred to L2 production.

4.7. Conclusion

The results for /d/ and /ð/ production show that L1 surface realisations transfer to the L2 but are only correctly produced in the contexts where these segment surface in the L1. The result is best explained by the transfer of L1 surface segments together with that of the L1 underlyin-to-surface mapping, which could explain why Catalan speakers pronounce initial /d/ and intervocalic /ð/ authentically but not initial /ð/ and intervocalic /d/.

We found that the results for production of English /d/ and /ð/ by Catalan speakers are consistent with hypothesis 5 (or transfer of L1 Underlying Segment as any L1 Surface Segment with L1 Underlying-to-Surface Mapping).

CHAPTER 5

PRODUCTION EXPERIMENT 2: POLYMORPHEMIC WORDS

In the previous chapter, it has been shown that the production of English /d/ and /ð/ by Catalan learners is crucially determined by the distribution of these segments in their L1. However, all the words that were used in the experiment reported in the previous chapter were monomorphemic. Here I want to test whether morphological configuration could affect the production of English words by L2 speakers. Therefore, I try to find out whether Catalan learners of English show the same behaviour in the production of polymorphemic words. I replicated an experiment done by Eckman and Iverson (1997) where they examined whether Spanish spirantisation of intervocalic /d̪/ showed more in derived or in non-derived words. In this study, we want to test whether derived words are less accurately pronounced than non-derived words by L2 learners, as they found in their study. They did not run statistical tests on their data and that is something I want to add to my pseudo-replication of their study, in order to examine whether the differences found in my data, if any, reach significance.

5.1. Introduction

This chapter examines whether words which are made of one single morpheme (i.e. monomorphemic words) show a more target pronunciation than those words which are made of more than one morpheme (i.e. polymorphemic words) after a derivational process. I replicated Eckman and

Iverson's (1997) experiment and determined whether we also observed a more accurate production of /d/s to be found in non-derived than in derived words.

In the literature review, the work by Eckman and Iverson (1997; Eckman et al., 2003) where they analysed the transfer of the spirantisation postlexical rule onto the English spoken by Spanish speakers was described. Spirantisation also exists in Catalan as a postlexical rule and, therefore, we can test their hypotheses in the speech of our speakers, who are bilingual in Catalan and Spanish. We will examine the production of English intervocalic /d/ by Catalan speakers.

As Eckman and Iverson's studies were done within the Lexical Phonology framework, we should first have a look at what the assumptions of their work are. Lexical Phonology distinguishes between two different types of rules: lexical and postlexical rules. Lexical rules are said to apply only to derived forms (e.g. the velar softening rule that makes the velar stop in *electric* become an alveolar fricative in the derived form *electricity*) and the result of applying these rules will never result in a form with non-contrastive underlying segments (i.e. the output of the rule application will never include allophones). On the other hand, postlexical rules apply across the board to derived ad non-derived words and their output can contain segments that are not part of the phonemic inventory of the language. As Eckman and Iverson (1997) state, these features of the different rules are the result of the application of two basic principles: the Structure Preservation Principle and the Derived Environment Constraint. The Structure Preservation Principle states the output of any lexical rule can only contain phonemes, whereas non-contrastive segments are the result of the application of postlexical rules. The Derived Environment Constraint describes the fact that lexical rules apply only in derived environments

whereas postlexical rules apply across the board. Eckman and Iverson posit that rules can transfer from L1 to L2 and in doing that they can become rules of a different status in the interlanguage (e.g. spirantisation can be applied as a lexical rule in the interlanguage). Such a transfer parallels the process described in our model when a surface realisation is transferred to L2 inventory.

We expect Catalan speakers of English to show one of the following possible patterns in their behaviour:

1. Catalan spirantisation does not transfer to the L2 regardless of the morphological makeup. Therefore, Catalan speakers will pronounce stops in both *ladder* [ˈlædə] and *madder* [ˈmædə]. That means that there is no transfer of the L1 postlexical rule and L2 production is consequently target-like.

2. Catalan spirantisation only transfers to the English non-derived words. In this case, Catalan speakers will mispronounce *ladder* as [ˈlæðə], whereas they will pronounce *madder* correctly as [ˈmædə]. It is impossible to explain this behaviour by referring to the status of the L1 postlexical rule in L2.

3. Catalan spirantisation transfers to the English derived words only. Catalan speakers' production of *ladder* will be correct (i.e. [ˈlædə]), whereas they will still pronounce *madder* as [ˈmæðə]. For this hypothesis to hold, the L1 postlexical rule has a status of lexical rule in L2, and that is why spirantisation only happens to apply to derived forms.

4. Catalan spirantisation transfers to both non-derived and derived English words. If this happens, Catalan speakers will pronounce *ladder* as [ˈlæðə] and *madder* as [ˈmæðə]. In this case, the L1 postlexical rule has also a postlexical status in L2, and that is why

it applies to both non-derived and derived words.

According to Eckman & Iverson (1997), the second possibility is impossible because of the assumptions in their Lexical Phonology approach. It is not possible for learners to apply an L1 postlexical rule to the derived L2 words only. The rules that affect derived words should have a lexical status, and therefore affect to both derived and non-derived words. However, if we assumed that prosody plays a role in L2 production, the second case could happen. According to the Prosody-Morphology Edge Alignment approach (Aronoff & Sridhar, 1983), there is a boundary at the end of the stem of words (e.g. at the end of *ladder* and at the end of *mad*). If there is such a boundary, then we would find cases 2 or 3, depending on whether the prosodic boundary blocks or promotes the application of the L1 postlexical rule in L2 speakers' interlanguage. If the boundary prevents spirantisation from applying, the result will be 2. If, on the contrary, the prosodic boundary favours spirantisation, then the result will be 3. However, if the prosodic boundary does not cause any effect, then we will either find case 1 or case 4.

In order to investigate the effect of morphological configuration on the production of intervocalic /d/, we replicated Eckman and Iverson's (1997) experiment.

5.2. First experiment: replication of Eckman & Iverson's (1997) experiment

5.2.1. Method

5.2.1.1. Stimuli

In Eckman and Iverson's paper (1997), the task they used for eliciting their data is explained in detail in the appendix to the article. Their task

involved showing the subjects a word on a card and making them read it aloud. Then, they were to turn the card over and they were given a cue for the kind of derived word they had to create (e.g. comparative, verb or adjective) on the initial word.

We devised two tasks which served us to elicit the non-derived and derived words.

First, subjects had to fulfil an oral fill-in-the-blanks task. They were asked to fill in the blanks orally when reading the whole sentence. The items they had to convert into derived forms ended in /d/ (e.g. lead). Therefore, after the derivation, the target phone [d] (e.g. lead > leader) was in intervocalic position.

e.g. The team which **leads** a championship is its _____.

(in which the target item was 'leader')

The second task consisted in having the subjects in our study read a word list.

5.2.1.2. Subjects

The subjects in the perception experiment and the monomorphemic production experiment served as subjects.

5.2.1.3. Procedure

The data for this study was collected in the sessions in which the data for the perception experiment and the production of monomorphemic words were elicited. The fill-in-the blanks task was the first task in the whole session and the reading of the word list followed.

5.2.2. Analysis

The data of the 20 Catalan subjects was analysed by two native speakers of English with phonetic training (MC and ZB). The data were coded in the same way as in the production experiment with monomorphemic words. That is, the transcriptions of target segments as [d], [d̪] and intervocalic [ɾ] was considered a good production of /d/. For target /ð/ items, tokens produced as [θ] were discarded.

Two separate one-way ANOVAs were run on the data to check whether the morphological configuration of words (i.e. whether words which are non-derived or derived) affected the spirantisation of intervocalic /d/. The tests showed that intervocalic /d/ was spirantised more often in derived than in non-derived words (MC: [$F_{(1, 19)}$ = 36.954; $p < .001$]; ZB: [$F_{(1, 19)}$ = 37.670; $p < .001$]). Case 3 in the predictions above is supported by the data.
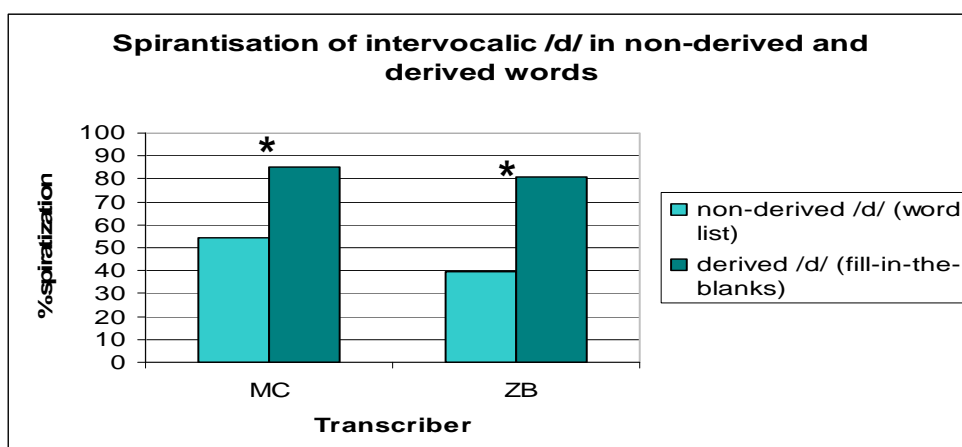

Fig. 5.1. Spirantisation of English intervocalic /d/ in non-derived and derived words when spoken by Catalan speakers of English.

However, a possible word frequency effect was checked. It could have

been the case that the non-derived words were actually easier words, or words which they are more likely to have come across than the target derived words. This factor could have created an artefact and affected the results. In order to check this effect, the CobLog value of the word forms used in the test were checked in CELEX. The CobLog is the logarithmic frequency value of each word in the Cobuild's corpus. A logistic regression was run with two predictors (i.e. non/derived word and frequency value) where the dependent variable was spirantisation.

Table 5.1. Results for the logistic regression with the derived/non-derived words and frequency predictors of spirantisation.

Predictors	B	S.Error	Wald	df	Sig.	Exp(B)
(non)/derived	-1.478	0.224	43.646	1	.000*	4.384
frequency	-0.132	0.153	.743	1	.389	.876
constant	1.571	0.201	61.159	1	.000*	4.814

Only the condition of whether the word was derived or non-derived reached significance. The frequency effect on spirantisation was ruled out.

Even though the findings seem to be consistent with case 3 and a frequency effect was rejected, a closer analysis of the experimental design made us think of a possible task effect[1]. The fill-in-the-blanks task might be more demanding than the reading task, in terms of processing. A difference in task demands could cause a difference in the production of /d/ in derived and non-derived words. We suspected that a task in which some thinking processing is involved (i.e. fill-in-the-blanks) could cause spirantisation (i.e.

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[1] Suggestion provided by Professor Bob Ladd, in a Postgraduate Conference at the Linguistic Department of the University of Edinburgh.

L1 post-lexical rule effects) to surface more often than in just a reading task.

5.3. Follow-up study

In order to get rid of the task confound, we used the tasks in the previous experiment (i.e. in order to be able to compare the results by different speakers) and we also created some new tasks which elicit both non-derived and derived words. At the same time, we also tried to control for the prosodic prominence of the target words elicited in each task.

5.3.1. Method

The production data were analysed auditorily by a native speaker of English (ZB, already mentioned in the previous chapter). This production experiment aimed at clarifying whether the morphological configuration of words affects the production of a given segment. Specifically, our study tested whether the production of intervocalic /d/ differed in monomorphemic and in polymorphemic words because of the derivational process involved in the polymorphemic – in this case, derived – words.

5.3.1.1. Stimuli

A series of materials were designed for this experiment. First, a number of words with intervocalic (and post /ɹ/) /d/ were checked in the CELEX database, which we also used in the previous experiment. The words

with the highest Cob Log value (i.e. the most frequent words) were chosen in order to obtain 20 non-derived and 20 derived words. Words used in the first study were also included in each group (10 in the group of non-derived words and 6 in the group of derived words) even though they were not the most frequent words, for the sake of comparison.

The words chosen for the experiment were included in four different types of task:

1. A fill-in-the blanks task

2. A grammaticality-judgements task

3. A reading task of prosodically-controlled sentences

4. A word list

First, the fill-in-the-blanks task was originally used in the first derivational study which checked the production of /d/ in derived words.

Second, in the grammaticality-judgement task, subjects were presented with pairs of sentences in which they had to choose the one they preferred and read it aloud. Sometimes the pairs involved a grammatically correct and a grammatically incorrect version of the same sentence. In other cases, it was just two possible structures in which they had to choose just one. Subjects thought they were doing a grammar test but their pronunciation was actually being examined. The 20 non-derived and the 20 derived items were included in the sentences, in non-prominent positions, more specifically, in a position with no pitch-accent. An example (in which the target item was 'study') would be:

- Jessie does not know if to study Medicine or Biology.
  Jessie does not know whether to study Medicine or Biology.

Third, the prosodically-controlled sentences had a regular structure. They were two sentences which were consecutively read aloud by the subjects. The sentences had the following form: "A word that means X is Y. Say Y for me". Y stands for the target item. The verb before Y in the second sentence was a monosyllabic verb, and it was one from a list of eleven different verbs. 40 filler sentences were used in this task. The first sentence placed the target item in the pitch-accent position, and the second one had it in non-prominent position after a verb which was different from the one in the pair preceding it.

And finally, the ten non-derived words, which had been included in the first study, were elicited by asking the same subjects to read them from notecards (check appendix D, for the answer sheets provided to subjects).

5.3.1.2. Subjects

Several tests picking 10 random speakers in the previous experiment showed that the difference in spirantisation in non-derived and derived words was still significant in a smaller sample. Therefore, data from other ten native Catalan speakers (6 female, 4 male) were collected. The subjects (mean age= 25, range 18 to 46 years) studied English at a language school in Palma. They were about to finish their Certificate of Advanced English (CAE) courses. They were adults and reported having normal hearing. They were paid for their participation. The requirements for eligibility were the same as those in the previous experiment. They should not have stayed in an English speaking country for more than two months and they should not have ever taken a course in phonetics.

5.3.1.3.   Procedure

The order in which the different tasks were performed was always the same so as to keep them in an order of decreasing productivity (i.e. the tasks which involve more thinking came first) and increasing formality. The tasks were performed in the order they were described in section 5.3.1.1.

The recording materials were a Sony TCD-D7 DAT recorder and a Sony ECM MS-907 microphone on a stand. The microphone was placed 20 centimetres away from the mouth of the speaker.

5.3.2. Analysis

The data collected from these 10 Catalan subjects were auditorily analysed by transcriber ZB. The sound files for each separate item was put in a script in which each word was preceded by a number and followed by a pause for the transcriber to write its transcription. The transcriber did not know what the target word was and was instructed to choose between [d] and [ð] as the sound which best describes the intervocalic or post [ɹ] segment in each word, or provide her own transcription if the item did not correspond to either of those phones.

The transcriber was blind to what the target words were. She was not provided with the spelling of the target word but was only asked to pay attention at the segment in the target position in the items she listened to.

The experimenter listened to the sentences to check the subjects' production of prosodic patterns. Overall, subjects tended to produce the non-prominent target word in the grammaticality-judgement task as non-prominent. They also pronounced the pitch-accented word at the end of the

first sentence in the pairs of prosodically-controlled sentences as prominent. However, most speakers failed to produce the target non-prominent word in the second sentence of the prosodically-controlled pairs as non-prominent. The pattern they should have used in the last case implies an elaborate understanding of the mechanisms used in English in order to indicate emphasis or contrast. Even though the subjects are advanced students of English, we had assumed that their language proficiency was more advanced than it actually was at least as far as prosodic competence is concerned, when we designed this experiment.

5.3.3. Results and discussion

As far as the statistical analysis is concerned, a one-way ANOVA was run on the data. This test had the morphological configuration of the word (i.e. derived or non-derived as its independent variable and spirantisation of /d/ as its dependent variable.

First, we ran the one-way ANOVA just on the data elicited in the fill-in-the-blanks task and the word list. This was done in order to check whether the results in this test are comparable to those in our first study.

Table 5.2. Spirantisation of intervocalic /d̪/ in the non-derived words (elicited in the word list task) and derived words (elicited in the fill-in-the-blanks task).

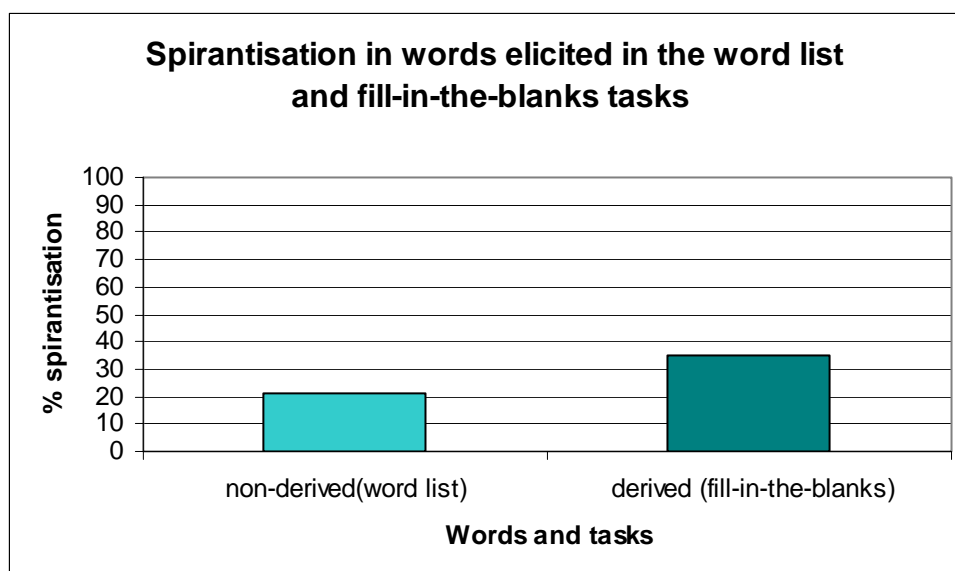|	Word list (non-derived words)	Fill-in-the-blanks task (derived words
Spirantisation of intervocalic /d̪/	21% 21/100 s.d. 16.633	34.99% 21/60 s.d. 16.575

Figure 5.2. Spirantisation in non-derived words (elicited in the word list task) and derived words (elicited in the fill-in-the-blanks task).

The results of the one-way ANOVA on the data elicited in the fill-in-the-blanks task and the word list show that the effect of the morphological configuration of words on production accuracy is also present, although it

just verges on the significance level [F (1, 9) = 4.814; p = .056] in this case. The effect is not as clear as in the first study but still noticeable. Therefore, we will have a look at the results in the two remaining tasks. It is important to remember that in each of these tasks we elicited both kinds of target words (i.e. non-derived and derived). Therefore, no possible task confound could be found there. When analysing the data in the pseudo-grammaticality judgement and the prosodically-controlled sentences pooled together, the one-way ANOVA test displays no significant difference between the production of /d/ in derived and non-derived words (F (1, 9) = .393; p = n.s.). When we analyse the data separately by task, the difference in spirantisation frequency between non-derived and derived words never reaches significance (pseudo-grammaticality judgement task: [F (1, 9) = .101; p = n.s.]; prosodically-controlled sentences: [F (1, 9) = .287; p = n.s.].
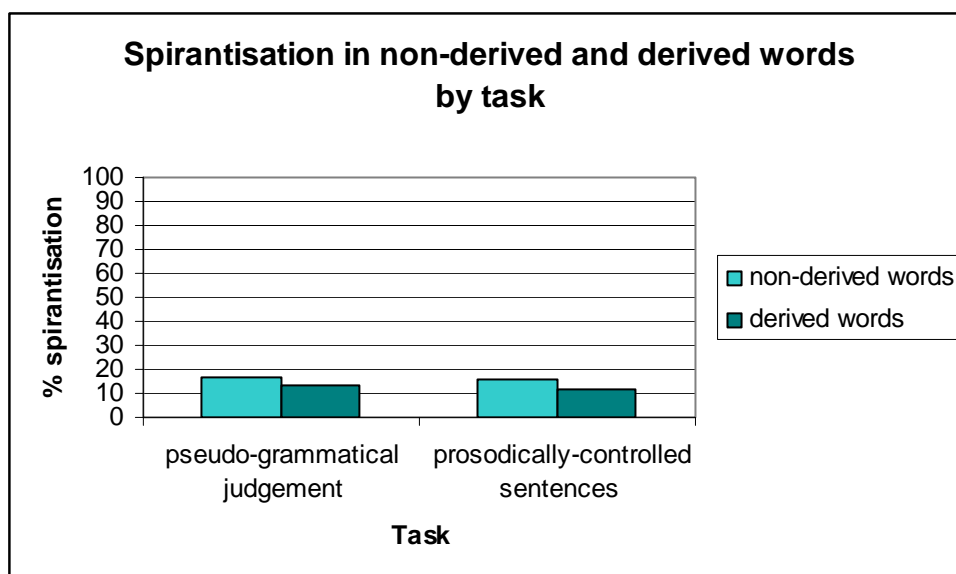

Figure 5.3. Spirantisation in non-derived and derived words elicited in two tasks.

Since we have found an almost significant difference between the rate of spirantisation in non-derived and derived words in the data elicited in the

fill-in-the-blanks task (for derived words only) and the word list (for non-derived words) but no difference was found when we analysed both derived and non-derived words elicited in a single task, then we could conclude that there was definitely a task effect in the first set of data we analysed. Therefore, the results in our first study showed the task effect even more clearly than the results in the present study, which only show a tendency towards significance.

It looks as though there could have been a task effect on Eckman and Iverson's (1997) data too because non-derived words were elicited in one task and derived words in another one. The non-derived words were the original words which were read, whereas the derived words were elicited by the cue on the reverse of the cards. In other words, the non-derived words were just read whereas the derived words were elicited by a more complex task. It is very similar to our word list and fill-in-the-blanks task, which was originally used in order to replicate their study. We could claim that the significant difference between spirantisation in non-derived and derived words in their study shows a task effect too. Perhaps dealing with derivation in L2 is more taxing for speakers' cognitive processing and, consequently, makes production a bit less accurate than when dealing with non-derived words. Thus, L2 speakers might be prone to realise L2 intervocalic /d/ with spirantisation more often in polymorphemic than in monomorphemic words, following L1 output constraints.

In Eckman, Elreyes and Iverson's paper (2003), they devised a different task in order to elicit non-derived and derived words. Nevertheless, the same criticism can be made about the design of their experiment. In their 2003 experiment, they elicited words by pictures followed by a definition of the target word. In the cases where the target item is a non-derived word that was all the information they were given. However, if the target item was a

derived word, a further step was involved: the subject was presented with a label saying '+ progressive' (i.e. to elicit a progressive '–ing' form) or '+ adjective' (i.e. to elicit an adjectival '–y' form). The added step involved in the elicitation of derived forms could also have played a role in obtaining results which are similar to the finding in their previous study.

One could argue that the difference between the pseudo-grammatical judgement task and the prosodically-controlled sentences task is in the number of items elicited in each one. The prosodically-controlled sentences contained twice as many target items as those in the pseudo-grammatical judgement task. The reason behind this was that the first occurrence was supposed to be in prominent position whereas the second one was to be in non-prominent position. However, the auditory analysis of the sentences confirmed that the both the first and second occurrences were realised as prominent. Therefore, we got rid of the second occurrence of each item, which could have been affected by being the repetition of a recently spoken target word. Even this subset of words did not show that the fact that words are derived or non-derived makes any difference on the transfer of spirantisation to English words ([$F_{(1, 9)}$ = .783; p = n.s.]).

Even though the difference is not significant, Figure 5.3. shows the pattern considered to be impossible by Eckman and Iverson (1997), i.e. case 2. Our subjects seem to spirantise intervocalic /d/ in non-derived English words more often than in derived words, when we elicit the two kinds of words in the same task. However, this difference does not reach significance but indicates that perhaps Eckman and Iverson's approach cannot account for what actually happens in L2 learners' production.

The data we displayed in Figure 5.3. includes the data in our first experiment and the most frequent items, according to CELEX. For a further analysis and to get rid of a possible frequency effect, we reanalysed the data

by taking out the data included in our replication of Eckman and Iverson's experiment (1997). Such an analysis showed no significant difference in transfer of spirantisation in non-derived and derived words, in none of the two tasks (pseudo-grammatical judgements: [F (1, 9) = 2.022; p = n.s.]; prosodically-controlled sentences: [F (1, 9) = 3.364; p = n.s.].)

5.4. Conclusion

The findings in this section are methodological rather than theoretical. It is important to bear in mind the design of the eliciting materials because the results of our experiments could be an artefact of that, as happened with the results in Eckman and Iverson's (1997) paper and in our replication of their study. We have to be careful in using the same kind of task when eliciting different type of data, if we want the results to be comparable.

The present study suggests that the morphological configuration of words does not affect the rate of usage of L1 allophonic rules in the English speech of Catalan learners. The fact whether intervocalic /d/ is in a monomorphemic or polymorphemic word does not affect the pronunciation of this phoneme.

CHAPTER 6
SUMMARY, DISCUSSION AND CONCLUSIONS

The present thesis explores the nature of the representation units in transfer processes when producing and perceiving contrasts in L2 which involve a redistribution of L1 phones. In this chapter we will attempt to summarise the findings in the thesis, discuss their implications and directions for further research.

6.1. Summary and discussion
6.1.1. Findings in perception and production

In order to be able to discern whether the production of English /d/ and /ð/ in absolute initial and intervocalic position by Catalan speakers is determined by the perception of these English phonemes, the perception test described in chapter 3 was devised.

The results in that experiment show that the perception of /d/ and /ð/ is very similar in both absolute initial and intervocalic position. Only the difference between the perception of initial and intervocalic /ð/ reached significance. Surprisingly, /ð/ was more accurately identified in initial than in intervocalic position. That is, /ð/ was more often accurately identified in the position where it does not exist in Catalan than in intervocalic position. This is exactly the opposite to what happens in their production of /ð/, which was found to be more accurate in intervocalic than in initial position, as diagnosed by native English listeners. These advanced learners of English still have more problems when they have to produce the /ð/ in a context where it does not occur in Catalan than they do when producing the voiced dental fricative in a context where it occurs in their L1. As far as perception

and production of /d/ are concerned, there is no significant difference in identifying /d/ in one position or the other but it is more accurately produced in absolute initial than in intervocalic position. Production results reflect the surface L1 distribution in our advanced Catalan learners of English, but their perception results do not.

In this case, the relationship between perception and production of /d/ and /ð/ shows that it is not possible to predict how production will be from the perception results. It is hence always crucial to check the way subjects in production studies perceive those target items in the target positions in case the problems in production arise due to a problem in perception, as assumed in Flege's SLM model (1987, 1995), for example. However, our data do not reflect this conditioning in a simple and clear-cut way. The production of initial /d/ and intervocalic /ð/ shows ceiling effects whereas the production of intervocalic /d/ and initial /ð/ shows around 60% accuracy. On the other hand, accuracy in segment identification is around 75% in all cases but identification of intervocalic /ð/ is 66% accurate. Thus, the lack of a significant difference between initial and intervocalic /d/ in perception cannot account for such a difference in production. Even though the difference between initial and intervocalic /ð/ is significant both in perception and production, the direction of the accuracy results are opposite in one skill and the other. Initial /ð/ is less accurately produced than intervocalic /ð/ whereas initial /ð/ is more accurately perceived than intervocalic /ð/. The asymmetry between the two skills had already been pointed out in the literature and authors either stated that perception was better than production or that it was the other way round. Here we find a complex behaviour and our finding is that we cannot say that Catalan speakers produce /d/ more accurately than they perceive it, for example. We should be very detailed in specifying the contexts where it is better perceived

than produced because we do not observe a plain and simple behaviour. The contexts where the target phones appear are crucial for distinguishing what the relationship between perception and production is like.

This finding suggests that problems in production of L2 surface segments cannot always be explained in terms of how well learners perceive them. Therefore, models which predict production only in terms of speakers' perception do not account for our results.

6.1.2. Findings regarding transfer of representations from L1 to L2

Due to the impossibility to account for L2 production in terms of L2 perception, we account for the production results in terms of transfer of L1 segments. The point we make here is about the nature of the representations that take part in this transfer process.

6.1.2.1. Hypothesis 5: Transfer of L1 Underlying segments as Any L1 Underlying Segment with Underlying-to-Surface Segment Mapping

With regard to our predictions for production, the results for /d/ and /ð/ are clearly consistent with Hypothesis 5. That is, the production of Catalan speakers with an advanced level of English still reflects the Catalan distribution on the way they produce the target English contrastive segments. Thus, our Catalan speakers produce /d/ significantly more accurately in initial than in intervocalic position. Conversely, their production of /ð/ is significantly worse in initial than in intervocalic position. Although they are at a relatively advanced stage in the learning process, their production still displays a behaviour that reflects their surface realisations in their L1. Their production rates of intervocalic /d/ and initial /ð/ are not above chance level.

6.1.2.2.   Our findings in relation to current phonological models

We therefore wonder whether L2 speakers actually refer to the L1 underlying representations at all when they speak in their L2. The hypothesis confirmed by our findings is that the L1 surface segments with their L1 context-conditioning are evident in the production of L2 underlying segments. It is important to notice that the default surface representation in Catalan /d̪/ is not the only one that surfaces as such in L2 production. Therefore, not only L1 underlying segments but also the mapping from underlying-to-surface segments transfers onto L2. The retrieval process could go directly from L1 underlying representations to L2 underlying representations and the L1 underlying-to-surface mapping would also transfer. Therefore, the L2 output shows a distribution like that in L1, although the advanced Catalan learners are starting to produce intervocalic /d/ and initial /ð/ accurately. This is consistent with theories that are output based (e.g. Optimality Theory, Exemplar-based Theory). Standard Exemplar Theory is output based because the main units involved in speech perception and production are output forms that are stored in the brain. In a way, we could postulate that our data shows that the L1 underlying representation is ignored in the process of L2 underlying (or surface realisation) production. I would rather suggest that L2 speakers might use underlying representations in the transfer process with the L1 underlying-to-surface mapping, although our results could also be accounted for by postulating that L1 surface forms transfer onto L2 production. We called the target segments in this study 'underlying representations' because they displayed no context-conditioned surface forms in the target language. What we have referred to as L2 underlying segments could also be referred to as L2 surface realisations, however.

The hypotheses we have devised make use of the traditional Generative Phonology approach in order to distinguish between lexical contrasts (i.e. underlying segments) and acoustic variable realisations (i.e. what we have called surface segments). Traditional Generative Phonology was the framework chosen for this study due to the clear definition of the different representational units which take part in the speech production and perception processes. These representational units have long been accepted by the linguistic community as existing, although some of them have been questioned by different scholars (e.g., Port & Leary, 2005).

Of course, the results in this research could be interpreted in terms of other current approaches to phonology, such as Optimality Theory and Exemplar Theory. Let us see what the interpretation of the results in such frameworks would be.

First of all, it is important to note that the relationship between the input and the output in OT is not equivalent to the relationship between the underlying and surface levels in Generative Phonology. OT does not impose any restrictions on the inputs that enter grammatical computation. They could but do not have to be lexical representations. Outputs can be mapped on infinite numbers of inputs. Therefore, the mapping in this case is different from that we assumed in the formulation of the hypothesis in the thesis. We do not claim that the mechanisms adopted in our model are equivalent to those in OT. Our data, however, admits an interpretation within the OT framework. In OT terms, the transfer of L1 surface realisations could be expressed as the transfer of L1 conditions on well-formed output forms onto L2. The ranking of the constraints on the output in Catalan could be transferred to the English interlanguage of the Catalan speakers and that would result in the behaviour we observe here. In OT, the ranking of constraints reflects the distribution for the Catalan allophones [d̪] and [ð]. The ranking of constraints in Catalan could be described as: *VdV>>*ð>>Ident[cont]. Here we have a context-specific markedness

constraint ranked above a context-free markedness constraint of the opposite value, both of which are ranked above a faithfulness constraint that preserves the input-output correspondence of that feature (i.e., [cont]). Such a ranking gives rise to complementary distribution: an output with different allophones, in which ð is not always the preferred candidate. The *VdV constraint dominates Ident [cont], which means that the appearance of [d] in intervocalic position is blocked. For Catalan learners to produce English-like outputs, they should rerank the constraints they have to the following: Ident[cont]>>*VdV , *ð. Our data could be interpreted as though this reranking is sometimes taking place because production of intervocalic /d/ and initial /ð/ is sometimes target-like, but not always. This mechanism of reranking was suggested by several scholars (e.g., Hancin-Bhatt & Bhatt, 1997; Broselow et al., 1998).

What is important to note is the different representational possibilities available to an OT analysis of our data. For example, the L2 lexical representations could be different. Let us assume that for the word *body* has /ˈbɒðɪ/as its lexical representation. Such a lexical representation does not allow for alternation between [ð] and [d] in the output. If production fluctuates between the stop and the fricative, a constraint such as *VðV is required. However, this is not a well-motivated constraint due to the fact that its output is marked. On the other hand, if we assume that the lexical representation for *body* is /ˈbɒdɪ/, Catalan learners have an interlanguage grammatical ranking influenced by their L1: *VdV>>Ident [cont]. Variability in the output can be explained by OT by claiming a ranking indeterminacy between *VdV and Ident [cont]. Thus, given our results, in an OT analysis framework we can only claim that /ˈbɒdɪ/ is the underlying representation and the indeterminacy in the order of the faithfulness constraint and of the Ident [cont] constraint is responsible for output variability.

In a more recent phonological framework, such as Exemplar Theory (Goldinger, 1998; Johnson, 1997; Pierrehumbert, 2001, 2003a, 2003b), the prediction our hypothesis makes could be reached by claiming that the most frequent exemplars of a given segment in L1 are transferred to L2. However, these are early days for the theory and certain details of the theory remain to be worked out as to which representations or realisations could transfer from L1 to L2, and what the unit of the exemplars (segmental, lexical, etc.) is. Although the Exemplar-based Theory was initially devised to explain speech perception (Johnson, 1997), Pierrehumbert has extended it to production (2001) and phonological acquisition (2003a). In principle, for an exemplar-based account to work, we should find that a lexical item is equally perceived and produced. The link between production and perception should be very transparent and straightforward in standard exemplar-based models due to the fact that they assume that tokens are stored and retrieved in their output form. Therefore, any difference between perception and production where production is less accurate than perception could be explained in terms of motor implementation, for example, but not in terms of the phonological model itself. The results in our study exhibit a complex correspondence between the perception and production of the target segments.

Our data cannot clearly test the relationship between perception and production in a framework like the Exemplar Theory because different items have been used in the experiments for each skill. The perception test was done with pseudo-English words, whereas the production test was done with actual English words. Our pilot perception study with minimal pairs of real words made us make up our mind due to a frequency effect in the answers by the Catalan learners of English. In the pairs, there was always an item which was much more frequent and familiar to the learners. And that seemed to play a role in their answers. Therefore, we cannot do a one-to-one comparison in perception and production for lexical items. The experiments

in this thesis were devised to test the accuracy in production and perception of segments in specific positions, not of lexical items. Further developments in the theory with respect to acquisition are expected to let us test this in the future.

One of the issues I would like to address with regard to L2 acquisition within the Exemplar Theory framework is whether, at the beginning, L1 and L2 exemplars are stored together in the lexicon and that is why the exemplars in the small L2 input is confused with the most similar abundant L1 input. For example, let us take two similar lexical items in Catalan and English and assume that the exemplars that play a role in production are at a lexical level (Goldinger, 1998): the Catalan verb form *badi* [ˈbaði] (1st. p. sg. present subjunctive: 'be heedless') and the English noun *buddy* [ˈbʌdɪ]. If Catalan learners of English had initially the exemplars of the Catalan and English lexical items stored together, the L2 surface production would clearly display the L1 conditioning. Perhaps through experience and learning, learners could start to store the similar L1 and L2 exemplars apart in order to create separate categories for L1 and L2, giving way to a more native-like proficiency in L2, in a similar way like Equivalence Classification works in Flege's SLM (1987, 1995). The common storage in L1 and L2 could also account for findings in research about L2 influence L1 production. However, the existence of pairs like those in the illustration above in L1 and L2 is unlikely to be very high. Thus, a standard model of Exemplar Theory would not predict a strong effect of transfer processes onto L2 production.

As shown by the findings of this study, Pierrehumbert's categories (2003a, b), which contain more detailed information about realisational features than the traditional abstract phoneme, would be good candidates for transfer processes from L1 to L2. They would be parallel to the underlying segments put forward in the model used for the formulation of our hypotheses.

Advanced Catalan learners of English do not seem to transfer L1 underlying segments only to their L2 speech production. That is, their surface L2 productions reflect the L1 underlying segment with the L1 underlying-to-surface mapping. We could wonder whether this is the case in L2 production by beginners. The production in beginners could reflect the L1 underlying segment transfer as only transferring /d̪/ to the L2 contexts that match with those in L1 (i.e. in initial position), as described in our hypothesis 4. The transfer process could involve the L1 underlying segment and then extend it to all the contexts where it exists in L2 after a mapping to a default realisation. Such a transfer would result in the accurate production of target /d/ but non-target-like realisations of /ð/, as described in hypothesis 1. Alternatively, the hypothesis confirmed by our data (i.e. hypothesis 5) could also hold for beginners but at a different degree. That is, the production of beginners could from the beginning reflect the L1 surface distribution in L2 production. Thus, they would produce target initial /d/ and intervocalic /ð/ very accurately from the start, but they would produce intervocalic /d/ and initial /ð/ very poorly. The difference with advanced learners would be in the degree of accuracy of production of /d/ in intervocalic position and /ð/ in initial position. Due to the accumulation of language experience, learners might acquire in due time the accurate pronunciation of these segments in the contexts where they do not exist in Catalan.

Future research could compare the results from this study with data from Catalan speakers of English who live in an English-speaking country in order to check whether there is a significant difference in the production of /d/ and /ð/ across groups. If there was such a difference, then we could attribute the results to the difference in the amount and quality of input. Frequency in the input could be studied within the Exemplar Theory framework.

6.1.3. Findings regarding the phonology-morphology interface

Apart from the nature of representations that are transferred from L1 onto L2 production, this thesis has also focused on whether the interaction of morphology with phonology could play a role in accuracy in production. In our production experiment on polymorphemic words I have shown that there is no evidence that the phonology-morphology interface plays a role in the production of L2 segments. Advanced Catalan speakers do not produce derived English words with intervocalic /d/ more often with spirantisation than non-derived English words with intervocalic /d/. The most interesting finding of this section is methodological, rather than theoretical. We have proved that designing an unbalanced experiment could distort the results and provide us with misleading findings. The difference in production between non-derived and derived words in Eckman and Iverson (1997) and in Eckman et al. (2003) could be an artefact of the tasks used in order to elicit the data, as we showed in Chapter 5. The tasks they used for speakers to be aware of the derivational structure of words made a difference in the processing load of the derived and the non-derived words. When we used tasks that aimed to replicate those they used, we found a tendency towards significance in the frequency of spirantisation of target English intervocalic /d/, with derived words showing a spirantised production more often than non-derived words. However, when both derived and non-derived words were elicited in the same task (and, therefore, subjects' attention was not drawn to the fact that they were dealing with derived words), there was no difference in frequency of spirantisation depending on the kind of words. Our findings provide further evidence for the fact that the morphological configuration of words does not affect the L2 production of segments that undergo alternations in the L1. They treat both derived and non-derived words alike, at least with respect to their success in producing these segments.

6.1.4. Where does this study stand in relation to the literature on L2 production of allophonic splits?

As pointed out in the literature review section, attention has been devoted to studying the perception of new L2 contrasts but little to production of L2 contrasts which are formed by already existing segments in allophonic variation in L1. Zampini (1994) already pointed out the fact that having a contrast in your L1 hinders the acquisition of such phones when they do not contrast in L1. Her study was exactly the opposite to what we have studied here. That is, she studied how American English speakers acquired Spanish spirantisation. She suggested that actually having contrastive /d/ and /ð/ in their language made the subjects in her study show a less accurate production of intervocalic Spanish [ð] with respect to the other intervocalic Spanish stops: [β] and [ɣ]. In an L2 acquisition context, dealing with a contrast in one language that does not constitute a contrast in the other – whether the contrast is to be acquired or lost – seems to really constitute a difficulty in acquisition. The Catalan subjects in the current study still display non-accurate production of target intervocalic /d/ and initial /ð/, even though they are advanced learners of English. Ideally, we could further test the importance of contrast in L2 acquisition if we could find a situation where two surface forms of the same underlying segment existed in two different languages but with distributions that did not match. However, the phonological conditioning and the universal tendencies followed by it make it difficult for such a scenario to be found.

The studies by Eckman and colleagues (Eckman & Iverson, 1997; Eckman et al., 2003) have only focused on L2 production of /d/ in intervocalic position, as the main aim of their research was to examine the rate of spirantisation in English spoken by Spanish speakers. Therefore, the

production of L2 /d/ in initial position is assumed to be very accurate, although they do not provide such evidence, since they only focus on the rate of application of the L1 spirantisation rule by Spanish speakers of English. Thus, the present study is more systematic not only in that it is not biased on one direction or the other in this respect, but also in that it presents a comparison in both relevant contexts with statistical treatment of the results.

As for Brière's paper (1968), the findings regarding acquisition of Vietnamese /t/ and /tʰ/ by English speakers are not further supported by our data. He reported that his subjects produced /t/ in initial position more accurately than /tʰ/ in non-initial position. Therefore, his finding interpreted in terms of our hypotheses is that underlying segments play a more important role in transfer process since the underlying representation /t/ is transferred to the contexts where it is not produced as such in English (i.e. in initial position). However, the English surface segment [tʰ] is not actually transferred to the underlying level in L2. Thus, those findings support hypothesis 1. The difference in the results between his study and ours could have been due to the difference in experimental design. As already pointed out in the literature review, the experimental setting was somewhat artificial as Brière created an artificial language acquisition setting for his study and did not use real American English learners of Vietnamese. Therefore, the findings in the present study represent a more accurate picture of the perception and production of learners in a real L2 acquisition context than those in Brière's study.

The hypothesis our study is consistent with, namely, hypothesis 5, which stands for transfer of L1 Underlying Segment as any L1 Surface Segment with L1 Underlying-to-Surface Mapping, can also account for the results on the production of /s/ and /ʃ/ by Korean speakers of English in Eckman and Iverson (1997). Korean speakers, whose L1 has a phoneme /s/ which is realised as [ʃ] only before [i] and as [s] elsewhere, produced

target English /s/ followed by [i] as [ʃ]. Korean speakers possibly transfer the L1 underlying segment in the form of any L1 surface realisation plus an underlying-to-surface realisations mechanism. Consequently, their production of English /s/ and /ʃ/ reflects the distribution of those segments in their L1.

6.1.5. Methodological remarks

Transcription by phonetically trained native speakers of English worked well for our study due to the quality in the data recordings and the acoustic similarity between the target segments, for which an acoustic analysis would not have been appropriate. The manner of articulation of these consonants was clear to the transcribers, and they could confidently and consistently say whether the segment they heard was a stop or a non-stop. We are therefore confident that the results represent what a native English listener hears when listening to non-native speakers, since the manner of articulation is pretty prominent in the identification between a stop and a fricative or approximant segment with close place of articulation and voice. Of course, non-target productions and the interpretation of our subjects' utterances in real life situations would be crucial when minimal pairs such as *day* and *they* exist in the target language.

6.1.6. Implications and future directions

Since we obtained such results with advanced students of English, it would be interesting to carry out a longitudinal study, which assessed the production of our target phonemes at different levels of proficiency. The

challenge in designing such a study is to keep the aim of the study concealed from the subjects because the same individuals should be subjected to production and perception tests at different stages of their learning process. Another relevant study would be a cross-sectional study with groups of Catalan students with different proficiency levels in English. This kind of study would help us assess how the production of L2 underlying segments that have allophonic corresponding segments in L1 may develop over time as experience in L2 increases.

The present study also has practical implications for the teaching of L2 phonological contrasts. As learners' L2 production displays a clear transfer effect from the distribution of their L1 distribution of those sounds, it is important for the training in L2 production to be planned on the basis of a specific L1. Therefore, courses focusing on L2 pronunciation training should ideally group learners in terms of their L1.

In the future, this study could be replicated by studying different L1s and L2s showing the same phone distribution in the languages. For example, we could study how American English speakers of Spanish produce the flap in post-stressed intervocalic position (i.e. one of the contexts in which flapping occurs in their English variety) and in absolute final position. Such a study might provide further support to the findings of the thesis.

6.2. Conclusions

This thesis constitutes another step forward towards the understanding of the roles played by different representation units in production of L2 contrasts. The production of L2 contrasts which do not exist in the learners' L1 is not completely accurate even at an advanced proficiency level. This study provides evidence for a possible active role of L1 phoneme, taken in the form of any of its L1 surface realisations, and an underlying-to-

surface realisation mechanism in transfer processes to L2 production. Although the hypotheses were devised according to the traditional Generative Phonology representational units, an account of our results in terms of more recent phonological theories, like Optimality Theory and Exemplar Theory, is also provided.

Accuracy in L2 production does not seem to depend on the morphological configuration of words, contrary to what has been suggested by Eckman and colleagues (Eckman & Iverson, 1997; Eckman et al., 2003). Our experiment on production of polymorphemic words proves that the findings by Eckman and colleagues seem to have been an artefact of the tasks they used for their data elicitation.

As the production results obtained cannot be attributed to the way the target L2 phonemes are perceived in the same phonetic contexts, our study contributes to the already existing body of literature about the relationship between production and perception by confirming the non-straightforward correspondence between both skills. Our results indicate that models on L2 phonology which make predictions for L2 production solely in terms of L2 perception should be revised. Thus, the generally more and more assumed important role played by L2 perception on L2 production should not systematically be taken for granted.

As shown here, acquisition of contrasts in L2 phonology deserves further study due to the complexity of the factors involved in the creation of categories which are not present in L1. The new phonological models look like they offer us different ways to approach the issue and provide us with powerful insights into the topic.

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APPENDICES

Appendix A

Questionnaire

Answer this brief questionnaire:

- Date:

- Name:

- Age:

- Could you tell me what is the longest period of time you have ever spent in an English speaking country?

- Have you ever taken a specific course on phonetics?

- Do you have any hearing problems?

- Do you have close relatives from Andalusia or Majorca?

Thank you for your collaboration

Appendix B

Analysis of /d/ and /ð/ by a speech recogniser

The speech recogniser used for the analysis of the production data was based on a Hidden Markov Model (HMM)[1]. The set-up of the recogniser was very simple. There was one monophone (i.e. context-independent) model per phoneme. Each model had 3 states and the output distributions were single Gaussians. The models we used were trained on American English data from the Resource Management corpus (Price, Fisher, Bernstein & Pallett, 1993, 1996) available from the University of Pennsylvania Linguistic Data Consortium.

We did a forced alignment of these models to our data. Namely, we provided the recogniser with the phoneme sequence for each word. For each word, we wrote two transcriptions: the right one and the one with the other member of the pair (i.e. /d/ vs. /ð/, and /b/ vs. /v/). For example, for the word *ladder*, we provided the recogniser with the following transcriptions: /ˈlædər/ and /ˈlæðər/. Then, the likelihood assigned by each model to its region of data was normalised for duration and used for comparing how well different tokens of a phoneme matched the trained HMMs. Thus, we obtained a likelihood figure for each transcription and the one that was closer to 0 indicated the transcription that best fit the input of the recogniser. Whenever another possible English phoneme was perceived in the auditory analysis, the speech recogniser was provided with a transcription including such a phoneme and the likelihood for the three transcriptions was compared.

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[3] I am grateful to Dr. Simon King, who prepared the models used in this analysis to suit our specific goals.

Table b.1. Total agreement ratio and % agreement between analysers.

	MC vs. ZB	MC vs. recogniser	ZB vs. recogniser
Total agreement ratio	208/240 items	125/240 items	127/240 items
%	86.67% agreement	52.08% agreement	52.91% agreement

From this first analysis, it is clear that the agreement between the two phonetically trained English transcribers is much higher than that between any of the human transcribers and the speech recogniser.

Chi-square tests were run on the total numbers of agreements between analysers. The agreement was highly significant between MC and ZB (χ^2= 129.067; df= 1; p< .001) whereas the agreement between the human transcribers and the recogniser did not reach significance (MC vs. recogniser: χ^2= .417; df= 1; p= n.s.; ZB vs. recogniser: χ^2= .817; df= 1; p= n.s.).

In Table b.2., we can observe the rate of segments classified as being target-like. The ratios are more similar in the transcription between human analysers than between any of them and the recogniser.

Table b.2. Ratios and percentages of correct production in separate analyses by analysers[2].

	MC	ZB	Recogniser
Initial /b/	27/27= 100%	27/27= 100%	3/27= 11.11%
Intervocalic /b/	20/33= 60.60%	24/33= 72.72%	2/33= 6.06%
Initial /v/	15/27= 55.55%	19/27= 70.37%	21/27= 77.77%
Intervocalic /v/	40/45= 88.88%	40/45= 88.88%	43/45= 95.55%
Initial /d/	25/29= 86.2%	25/29= 86.2%	3/29= 10.34%
Intervocalic /d/	10/25= 40%	12/25= 48%	4/25= 16%
Initial /ð/	9/23= 39.13%	16/23= 69.56%	20/23= 86.95%
Intervocalic /ð/	29/31= 93.54%	29/31= 93.54%	28/31= 90.32%

Separate chi-square analyses were ran on the data. When the transcriptions by MC and ZB were identical (i.e. shaded cells in Table 2), a single chi-square analysis was performed comparing the figure in the human transcribers' cell with that in the speech recogniser's cell.

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[2] Shaded cells in the same row indicate identical figures by different analysers.

Table b.3. Results of chi-square tests run on the analyses for a given phone in a given position by different analysers.

	Chi-square results		
Initial /b/	Human vs. recogniser χ^2= 43.2; df= 1; p< .001		
Interv. /b/	MC vs. ZB χ^2= 1.091; df= 1; p= n.s.	MC vs. recogniser χ^2= 22.091; df= 1; p< .001	ZB vs. recogniser χ^2= 30.715; df= 1; p< .001
Initial /v/	MC vs. ZB χ^2= 1.271; df= 1; p= n.s.	MC vs. recogniser χ^2= 3; df= 1; p= n.s.	ZB vs. recogniser χ^2= .386; df= 1; p= n.s.
Interv. /v/	Human vs. recogniser χ^2= 1.394; df= 1; p= n.s.		
Initial /d/	Human vs. recogniser χ^2= 33.419; df= 1; p< .001		
Interv. /d/	MC vs. ZB χ^2= .325; df= 1; p= n.s.	MC vs. recogniser χ^2= 3.571; df= 1; p= n.s.	ZB vs. recogniser χ^2= 5.882; df= 1; p= n.s.
Initial /ð/	MC vs. ZB χ^2= 4.293; df= 1; p= .038	MC vs. recogniser χ^2= 11.29; df= 1; p< .001	ZB vs. recogniser χ^2= 2.044; df= 1; p= n.s.
Interv. /ð/	Human vs. recogniser χ^2= .218; df= 1; p= n.s.		

Table b.4. Percentage of correct production of /d/ and /ð/ by Catalan speakers, as analysed by the speech recogniser.

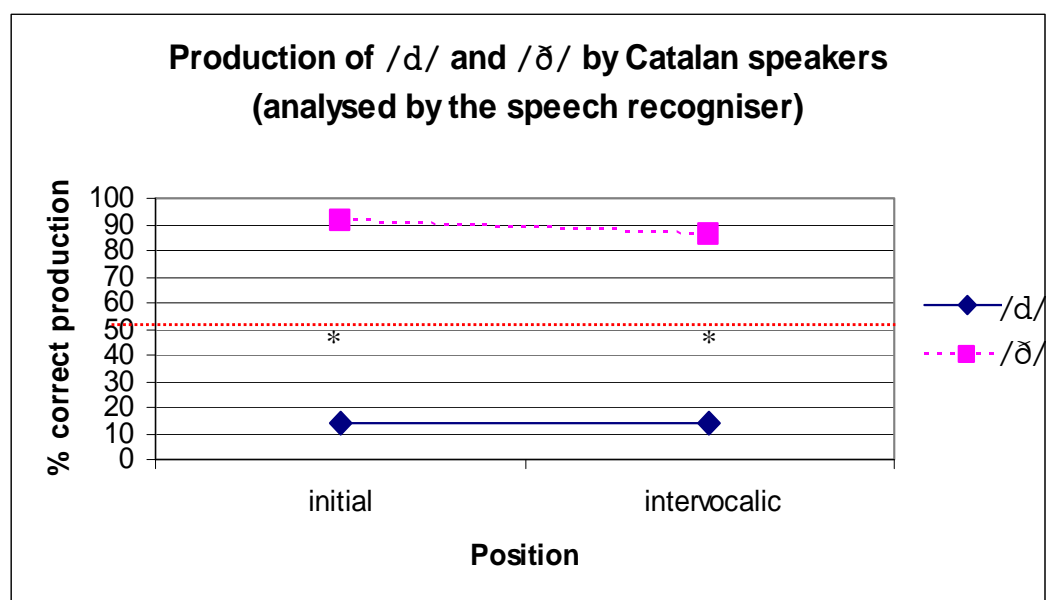|	POSITION	
	Initial	Intervocalic
/d/ produced as /d/	14.22% SD 9.75	13.66% SD 9.95
/ð/ produced as /ð/	91.46% SD 9.66	86.12% SD 19.65

(From Cortés, 2001)

Figure b.1. Total correct production of /d/ and /ð/ by Catalan speakers.

(From Cortés, 2001)

Appendix C

List of words elicited in the production experiment 1

List of words on notecards read aloud in the production experiment

Initial /d/	Initial /ð/	Intervocalic /d/	Intervocalic /ð/
desk	them	odour	brother
dance	there	ladder	rather
differ	thence	Cheddar	Northern
distant	this	sturdy	gather
domestic	though	murder	weather
dense	that	Gordon	worthy
DAT	those	garden	blather
dare	they	bladder	Southern
doze	they've	sudden	other
day	then	udder	bother
Dave	than		
den			
Dan			

Appendix D

Materials used in the production experiment 2

Use a derived form of the word provided in bold type to fill in the blanks.

Example:

A person who **teaches** is a <u>teacher</u>.

See that lady who is <u>playing</u> (**play**) bridge.

Stirling is **small** but Oban is even <u>smaller</u>.

Do the same with the following sentences:

- A team who **leads** a championship is its _____.
- The music is not very **loud**. Could you play it a little bit _____?
- My blood is **red** but your blood is _____ than mine.
- People say that Paul is **mad** but I think that Jessie is _____ than him.
- A person who **reads** for pleasure is a _____.
- This car is **odd** but I have seen another one that is _____ than this one.

Read these pairs of sentences in silence and read aloud only the sentence you prefer in each pair:

- I'd like to have a full body massage every week.
  I'd like having a full body massage every week.

- We should start heading home when the party will go wild.
  We should start heading home when the party goes wild.

- They told we have to order drinks at the counter.
  They said we have to order drinks at the counter.

- Helen was hiding beautiful flowers behind her back.
  Helen was hiding beautiful flowers over her back.

- Eve has a much louder voice than Helen's.
  Eve has a much louder voice than Helen.

- I hope the book is ready for printing when we leave next month.
  I hope the book is ready to print when we leave next month.

- This month we are needing an accountant to help us keeping an eye on our finances.
  This month we are needing an accountant to help us keep an eye on our finances.

- Lynda won the monthly garden competition last April.
  Lynda has won the monthly garden competition last April.

- The guitar player ordered a Bloody Mary at the end of his performance.
  The guitar player asked a Bloody Mary at the end of his performance.

- Jessie does not know if to study Medicine or Biology.
  Jessie does not know whether to study Medicine or Biology.

- Some people keep nodding off even if they don't know what you are talking about.
  Some people keep nodding off until they don't know what you are talking about.

- He intends to make me believe that Christmas comes halfway in the middle of winter.

He pretends to make me believe that Christmas comes halfway in the middle of winter.

- A beautiful lady with flowers came in the shop to try a purple hat on.
  A beautiful lady with flowers came in the shop to try on a purple hat.

- Michael Jackson is a much odder dancer than Prince, according to Julio Bocca.
  Michael Jackson is a much odder dancer than Prince, as to Julio Bocca.

- Our neighbours' sudden death shocked us all.
  Our neighbours' sudden death shocked all of us.

- Steve has been convicted with the brutal murder of Melissa Grant.
  Steve has been convicted of the brutal murder of Melissa Grant.

- Please, don't tell Big Daddy Redstone my book is missing.
  Please, don't tell Big Daddy Redstone my book went missing.

- You have to have a gentle steady hand unless you want to become a surgeon.
  You have to have a gentle steady hand if you want to become a surgeon.

- Joe is quickly spreading the notice about his new job.
  Joe is quickly spreading the news about his new job.

- My friend Jack lives in the permeable border between Texas and Mexico since 1956.
  My friend Jack has lived in the permeable border between Texas and Mexico since 1956.

- Yale has been a lot harder place to get into since 1978.
  Yale was a lot harder place to get into since 1978.

- It is always better to share a heavy burden of work than to do everything oneself.
  It is always better to share a heavy burden of work to do everything oneself.

- This morning I found Beth when she got a tin of milk powder with Vitamin D.
  This morning I met Beth when she got a tin of milk powder with Vitamin D.

- You can find a much wider range in our shop in the end of that street.
  You can find a much wider range in our shop at the end of that street.

- I think I'll need a long ladder with hooks to fix the problem on the roof.
  I think I'll need a long ladder with hooks to fixing the problem on the roof.

- Your parents must think that I'm a much madder woman than some of your previous girlfriends.
  Your parents must think that I'm a much madder woman than any of your previous girlfriends.

- The herb has a characteristic odour of onions when cooked.
  The herb has a characteristic odour of onions if cooked.

- Actually their company is leading the market due to the launching of their new product.
  Currently their company is leading the market due to the launching of their new product.

- You should keep adding flour until the dough does not stick to your fingers no more.
  You should keep adding flour until the dough does not stick to your fingers anymore.

- Sandy was a reliable sturdy woman in her early sixties.
  Sandy was a reliable sturdy woman in his early sixties.

- It has been proved that breast feeding is crucial to prevent allergies in the newly born babies.
  It has been proven that breast feeding is crucial to prevent allergies in the newly born babies.

- We had to buy a clean bladder for Haggis if we went to a Scottish cooking workshop.
  We had to buy a clean bladder for Haggis when we went to a Scottish cooking workshop.

- Lorna is the spiritual leader in a sect, which attracts young and weak people.
  Lorna is the spiritual leader in a sect that attracts young and weak people.

- I prefer yellow Cheddar crackers to bagels.
  I prefer yellow Cheddar crackers than bagels.

- This week John is riding his bike to work because his car is out of order.
  This week John is riding his bike to work because his car is not working.
- Please, don't tell Mr. Gordon Whitehead the story on the cat.
  Please, don't tell Mr. Gordon Whitehead the story about the cat.

- As for Angie, she was wearing a much redder jacket than she was shoes.
  As regards Angie, she was wearing a much redder jacket than she was shoes.

- Mary is a linguistics reader in Ohio State University since 1993.
  Mary has been a linguistics reader in Ohio State University since 1993.

- The farmer didn't know that the best udder for milking comes from the left side of the cow.
  The farmer ignored that the best udder for milking comes from the left side of the cow.

- John loved reading comics since he was very young.
  John's loved reading comics since he was very young.

Read these sentences aloud:

➢ A word that means 'decoding' is 'reading'.
> Say 'reading' for me.
➢ A word that means 'giving' is 'handing'.
> Add 'handing' for me.
➢ A word that means 'crashing' is 'breaking'.
> Claim 'breaking' for me.
➢ A word that means 'person' is 'body'.
> Read 'body' for me.
➢ A word that means 'guide' is 'leader'.
> Shout 'leader' for me.
➢ A word that means 'ask for' is 'order'.
> Cite 'order' for me.
➢ A word that means 'prepared' is 'ready'.
> State 'ready' for me.
➢ A word that means 'directing' is 'leading'.
> Cry 'leading' for me.
➢ A word that means 'higher' is 'taller'.
> Quote 'taller' for me.
➢ A word that means 'giving food' is 'feeding'.
> Yell 'feeding' for me.
➢ A word that means 'paradise' is 'garden'.
> Type 'garden' for me.
➢ A word that means 'small' is 'tiny'.
> Say 'tiny' for me.
➢ A word that means 'physician' is 'doctor'.
> Add 'doctor' for me.
➢ A word that means 'huger' is 'bigger'.
> Claim 'bigger' for me.
➢ A word that means 'instructor' is 'reader'.
> Shout 'reader' for me.
➢ A word that means 'taking on' is 'adding'.
> Cite 'adding' for me.
➢ A word that means 'examine' is 'study'.
> Read 'study' for me.
➢ A word that means 'igniting' is 'lighting'.
> State 'lighting' for me.
➢ A word that means 'faster' is 'quicker'.
> Cry 'quicker' for me.
➢ A word that means 'centre' is 'middle'.
> Quote 'middle' for me.
➢ A word that means 'woman' is 'lady'.
> Yell 'lady' for me.

➢ A word that means 'more spacious' is 'wider'.

     Type 'wider' for me.

➢ A word that means 'going for a spin' is 'riding'.

     Say 'riding' for me.

➢ A word that means 'quick' is 'sudden'.

     Add 'sudden' for me.

➢ A word that means 'enjoying' is 'liking'.

     Claim 'liking' for me.

➢ A word that means 'weightier' is 'heavier'.

     Read 'heavier' for me.

➢ A word that means 'book' is 'volume'.

     Shout 'volume' for me.

➢ A word that means 'homicide' is 'murder'.

     Cite 'murder' for me.

➢ A word that means 'father' is 'daddy'.

     State 'daddy' for me.

➢ A word that means 'stable' is 'steady'.

     Cry 'steady' for me.

➢ A word that means 'bottom' is 'basis'.

     Quote 'basis' for me.

➢ A word that means 'child' is 'youngster'.

     Yell 'youngster' for me.

➢ A word that means 'craving' is 'longing'.

     Type 'longing' for me.

➢ A word that means 'pullover' is 'sweater'.

     Say 'sweater' for me.

➢ A word that means 'disseminating' is 'spreading'.

     Add 'spreading' for me.

➢ A word that means 'edge' is 'border'.

     Claim 'border' for me.

➢ A word that means 'outlet' is 'market'.

     Read 'market' for me.

➢ A word that means 'hirsute' is 'hairy'.

     Shout 'hairy' for me.

➢ A word that means 'obscure' is 'gloomy'.

     Cite 'gloomy' for me.

➢ A word that means 'load' is 'burden'.

     State 'burden' for me.

➢ A word that means 'firmer' is 'harder'.

     Quote 'harder' for me.

➢ A word that means 'concealing' is 'hiding'.

     Cry 'hiding' for me.

➢ A word that means 'bright' is 'radiant'.

     Yell 'radiant' for me.

- A word that means 'intelligent' is 'clever'.
  Type 'clever' for me.
- A word that means 'desk' is 'table'.
  Say 'table' for me.
- A word that means 'biking' is 'cycling'.
  Add 'cycling' for me.
- A word that means 'lacking' is 'needing'.
  Claim 'needing' for me.

- A word that means 'sprinkle' is 'powder'.
  Read 'powder' for me.
- A word that means 'entry' is 'access'.
  Shout 'access' for me.
- A word that means 'expressing assent' is 'nodding'.
  Cite 'nodding' for me.
- A word that means 'colouring' is 'dying'.
  State 'dying' for me.
- A word that means 'thinner' is 'slimmer'.
  Cry 'slimmer' for me.
- A word that means 'more entertaining' is 'funnier'.
  Quote 'funnier' for me.
- A word that means 'work' is 'labour'.
  Yell 'labour' for me.
- A word that means 'stair' is 'ladder'.
  Type 'ladder' for me.
- A word that means 'related to blood' is 'bloody'.
  Say 'bloody' for me.
- A word that means 'road' is 'highway'.
  Add 'highway' for me.
- A word that means 'directing' is 'heading'.
  Claim 'heading' for me.
- A word that means 'scent' is 'odour'.
  Read 'odour' for me.
- A word that means 'tough' is 'sturdy'.
  Shout 'sturdy' for me.
- A word that means 'urine container' is 'bladder'.
  Cite 'bladder' for me.
- A word that means 'cheese' is 'Cheddar'.
  State 'Cheddar' for me.
- A word that means 'thief' is 'robber'.
  Cry 'robber' for me.
- A word that means 'wet' is 'rainy'.
  Quote 'rainy' for me.
- A word that means 'essay' is 'paper'.
  Yell 'paper' for me.

- A word that means 'subject' is 'topic'.
  > Type 'topic' for me.
- A word that means 'cause' is 'reason'.
  > Say 'reason' for me.
- A word that means 'more intense' is 'louder'.
  > Add 'louder' for me.
- A word that means 'not religious' is 'pagan'.
  > Claim 'pagan' for me.
- A word that means 'university' is 'college'.
  > Read 'college' for me.
- A word that means 'blind' is 'curtain'.
  > Shout 'curtain' for me.

- A name that means superhero is 'Gordon'.
  > Cite 'Gordon' for me.
- A word that means 'more blood-coloured' is 'redder'.
  > State 'redder' for me.
- A word that means 'cow's mammary gland' is 'udder'.
  > Cry 'udder' for me.
- A word that means 'weirder' is 'odder'.
  > Quote 'odder' for me.
- A word that means 'power' is 'engine'.
  > Yell 'engine' for me.
- A word that means 'cupboard' is 'closet'.
  > Type 'closet' for me.
- A word that means 'crazier' is 'madder'.
  > Say 'madder' for me.
- A word that means 'paradise' is 'heaven'.
  > Add 'heaven' for me.
- A word that means 'taking' is 'catching'.
  > Claim 'catching' for me.

Please, read the following words aloud:

Sturdy

Odour

Gordon

Murder

Garden

Bladder

Sudden

Cheddar

Ladder

Udder