THE INFLUENCE OF SECOND LANGUAGE LEARNING ON SPEECH PRODUCTION BY GREEK/ENGLISH BILINGUALS

by

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Abstract

This study examined the voice onset time (VOT) of Greek and English voiceless stops (/p/, /t/, /k/) produced by 20 Greek/English. The participants read initially-stressed CVCV words in Greek and English carrier phrases and three English sentences that were evaluated for accentedness. Analyses indicated that the bilinguals produced English VOTs longer than those of Greek and shorter than those of English monolinguals. They distinguished stop categories in terms of VOT across languages, but not in all vowel environments. Although English and Greek VOTs were correlated, English VOT values for /p/ and /t/ did not differ significantly, while the Greek values did. Accentedness ratings were correlated with age of learning English, chronological age and length of residence in Canada, but not with English VOTs. These findings indicate that the relationship between L1 and L2 language systems is bidirectional and more complicated than has been portrayed so far.

Dedication

To my valuable friend Pandeli (Peter) Capadouca, to my family and my friends who believed in me and supported me.

Στην οικογένειά μου, τον πατέρα, τη μητέρα και τον αδελφό μου για όσα μου προσέφεραν και κυρίως γιατί ακόμη με αντέχουν.

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Especially, I would like to thank all my participants for being cooperative and grateful enough to offer some of their time towards my thesis' project. Without their help and encouragement, I would never have completed this project.

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CHAPTER 1: Introduction

1.1 Purpose of the Study

The present study belongs in the field of acoustic phonetics, focusing on the properties of some specific language sounds - voiceless stop consonants. In particular, it explores the voice onset time (VOT) values of voiceless stops in Greek and English as produced by late Greek/English bilinguals. This research also has relevance to the field of bilingualism, because it deals with Greek/English bilinguals and their phonological system. Although the majority of linguistics theories and research presuppose the situation of monolingualism, the reality of bilingualism is far from rare in the everyday world. The interaction of two or more language systems, especially at the phonological level, and the possible emergence of an "interlanguage" have been topics of interest in studies of bilingualism that appear to require more research. This study, the first one focusing on Greek/English bilinguals and their phonological system, will offer some insight into these topics.

This chapter is organized as follows: Section 1.1 covers the introduction to this research; it will first define VOT and the different types of VOT (section 1.1.1), as well as present a description of the Greek phonological system (section 1.1.2). Section 1.2 concerns the theoretical background of the study; it will discuss Best's ideas (1995, 2001) and the Perception Assimilation Model (PAM) (section 1.2.1); then it will refer to Flege's (1987a, 1987b, 1992) theoretical proposals such as the Speech Learning Model (SLM)

(section 1.2.2). Section 1.2.3 presents a literature review focusing on the most relevant studies of bilingualism and VOT. Section 1.2.4 is devoted to the issue of foreign accent, theories concerning accent and a review of the few studies that deal with accent along with VOT, as this study will attempt to do. The last section (1.2.5) presents the basic hypotheses and research questions of this study.

1.1.1 What Is Voice Onset Time (VOT)?

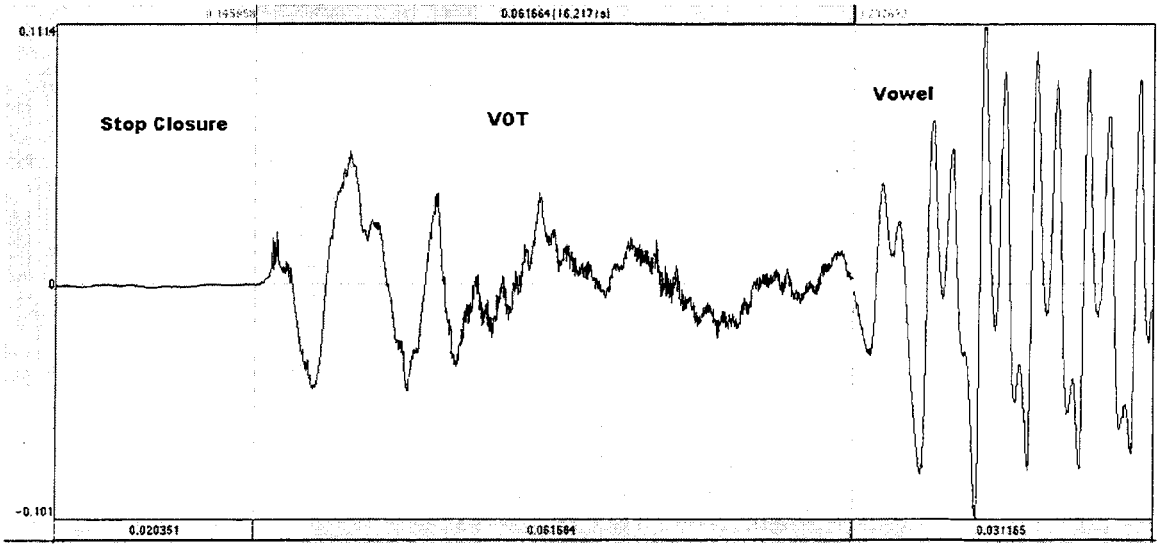
Stop sounds exist in all the languages of the world (P. Ladefoged, 1993; P. Ladefoged, Cho, Taehong, 2001; P. Ladefoged & Maddieson, 1996; Lisker & Abramson, 1964). An important acoustic parameter and articulatory feature in stop production is voice onset time (VOT). This acoustic feature helps to distinguish between stops with voicing lead and stops with short or long lag that have the same place of articulation. VOT is defined as "a period of voicelessness during and after the release of an articulation" (P. Ladefoged, 1993: 141), or according to Lisker and Abramson (Lisker & Abramson, 1967: 1), as "the time interval between the burst that marks release of the stop closure and the onset of quasi-periodicity which reflects laryngeal vibration." Therefore, the articulation of a stop begins with the stop closure, which is followed by a brief interval of high intensity noise (the release burst) and an optional period of aspiration before the beginning of the periodicity of the following vowel. The burst and the optional aspiration comprise what is defined as VOT.

When the voicing starts at the moment of release of a closure or shortly after it and there is no period of voicelessness after this release, it is a zero or short lag unaspirated stop. For unaspirated stops, VOT is short or zero and conventionally positive, since the voice onset "lags" behind release or starts simultaneously with the release.

When the voicing starts long after the release of the closure, it is a long lag aspirated stop; VOT is positive. When the voicing starts during the closure period, before the release of the burst, it is a stop with voicing lead; voice onset precedes or "leads" the stop release, thus the voice onset time is negative (Lisker & Abramson, 1967).

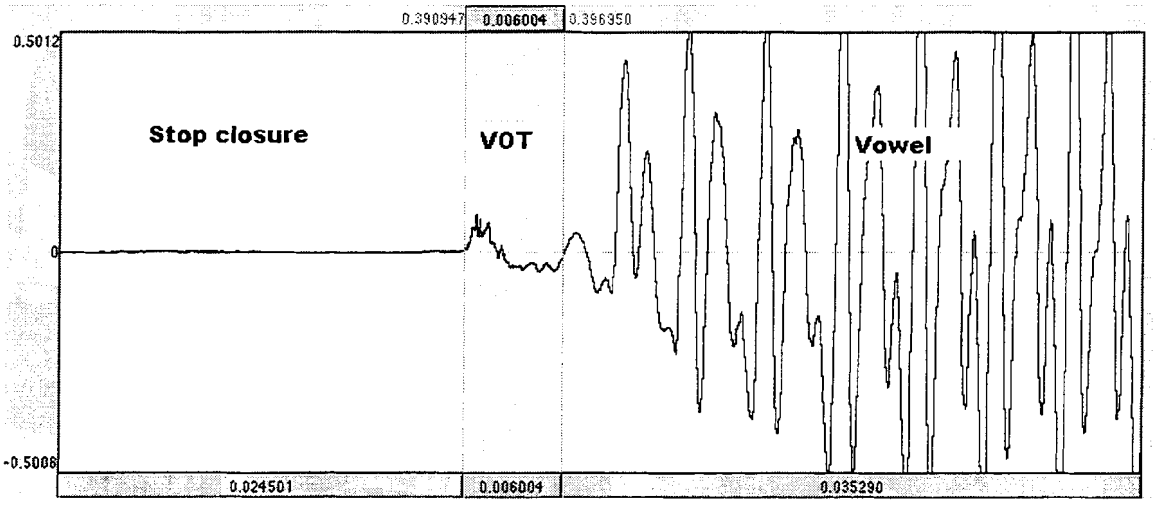
English voiceless stops are often long-lag aspirated stops. In Figure 1-1, a waveform representation of an instance of /p/ is presented from the word 'poker'.

Figure 1-1: Example of English VOT



Greek voiceless stops are typically short-lag unaspirated stops. In Figure 1-2, a waveform representation of /p/ is presented from the Greek word /pote/ ('when'). These two figures clearly show that VOT for Greek /p/ is much shorter than for English /p/.

Figure 1-2: Example of Greek VOT



1.1.2 Factors Affecting VOT

VOT differs based on the place of articulation; VOT is usually longer for alveolar than labial stops, and usually longer for velar than alveolar stops, as shown in most languages investigated by Cho and Ladefoged (1999) and Lisker and Abramson (1964). The former referred to the physiological/aerodynamic characteristics that account to some extent for the VOT differences due to the different place of articulation. These characteristics are: a) the volume of the cavity behind and b) in front the point of constriction, c) the movement of the articulators, d) the extent of the articulatory area, e) the changes of glottal opening area (only for voiceless stops) and f) the temporal adjustment between closure duration and VOT. To paraphrase Cho and Ladefoged's (1999) account, characteristics a) and b) are related to the pressure created before the release of a stop; c) and d) refer to the velocity with which an articulator can move resulting in different pressure, while a more extended contact area will result in slower release, since the Bernoulli effect pulls the articulators together. Characteristic e) refers to the fact that the glottal opening area decreases more rapidly for alveolar or labial stops

than velar ones because of the intraoral pressure, while f) indicates that there tends to be a fixed time for the vocal folds to be open, including both VOT and closure duration; thus, when closure is longer, VOT is shorter.

VOT and its phonetic realization differ with respect to the specific language (Cho & Ladefoged, 1999; P. Ladefoged, Cho, Taehong, 2001; Lisker & Abramson, 1964). Cho and Ladefoged (1999) suggested that VOT values are determined for the stops of a specific language according to the following processes: a) the language chooses from the three modal values for the phonological feature of VOT; voiced vs. voiceless unaspirated vs. voiceless aspirated, b) the language specific phonetic rules apply so as to assign target values for VOT, and c) the universal aerodynamic and physiological processes apply.

Previous studies have examined the effect of place of articulation and vowel environment on VOT values in various languages. For example, in English, Klatt (1973, 1975) reported that VOT is affected by the quality of the following vowel; to be more specific, VOT was greater when one of the high vowels, /i/ or /u/, followed. However, vowel duration did not seem to affect VOT in Klatt's study, though VOT was longer in one-syllable words than in two-syllable words. In addition, Lisker and Abramson (1967) reported that English VOT is longer in stressed syllables, but observed no effect of vowel environment.

For Greek VOT, Fourakis (1986) reported longer VOTs before high vowels, and longer values for velar stops than alveolar ones, which in turn were longer than for bilabial stops. He also referred to all other factors that have been proposed that affect VOT in general such as speaking rate/tempo, the number of syllables in the word, the

absence versus the presence of stress and the tenseness versus the laxness of the following vowel.

Studies on other languages include Flege et al. (1998), who reported that the VOT of Spanish/English bilinguals producing English words beginning with /t/ was longer in the context of high versus non-high vowels, and longer in one-syllable versus two-syllable words. Also, Flege (1991a), examining groups of English and Spanish monolinguals, showed that VOT values of word-initial stops are longer for /i/ than /ɛ/. Port and Rotunno (1999) reported that shorter VOT values in English voiceless stops occur with lax vowels than tense ones, while /a/ results in shorter VOT values than /i/ and /u/. Lastly, Magloire and Green (1999), when studying monolingual speakers of Spanish and English, indicated that VOT of voiceless stops increased when the speaking rate decreased for English monolinguals. However, Spanish monolinguals showed a small effect of speaking rate on VOT values, duplicating the results of Schmidt and Flege's study (1996) on English and Spanish monolinguals.

1.1.3 Greek Sound System

To examine Greek VOT, more information is needed on the Greek sound system. The Greek phonological system includes five phonemic vowels, universally, the most common vowel inventory. As shown in Table 1-1, there are two high vowels, /i/ and /u/; two mid vowels, /e/ and /o/; and the low vowel /a/. The front vowels are /i/ and /e/, the back vowels are /o/ and /u/, and /a/ is a central vowel. The acoustic characteristics of the Greek vowels are discussed by Fourakis et al. (1999).

Table 1-1: Table of Greek Vowels

	Front	Central	Back
High	i		u
Mid	e		o
Low		a	

The Greek phonological system also includes 28 distinct phonetic realizations of consonants that correspond to 19 phonemes (Koutsoudas & Koutsoudas, 1983; Philippaki-Warburton, 1992) plus the two affricates, /ts/ and /dz/, as shown in Table 1-2. However, there is a controversy regarding how many phonemes these consonants represent (Arvaniti & Joseph, 1999; Babiniotis, 2000; Nespor, 1999; Philippaki-Warburton, 1992). The phonemic identity of the voiced stop consonants [b,d,g] has been questioned (Arvaniti & Joseph, 1999, Malikouti-Drachman, 2001), even though there are minimal pairs of words that are distinguished by voiced versus voiceless stops. The arguments against the phonemic status of the voiced stops are that: a) they derive historically from Nasal+voiceless stop environments, b) the Nasal+voiced stop combinations alternate with voiced stops in Standard Modern Greek, and c) the environments that they occur in synchronically are specific and predictable. The phonemic identity of the approximant /j/ is also controversial, because it usually appears where there is or was an underlying /i/.

Table 1-2: Table of Greek Consonants

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Palatal	Velar
Plosive	p b		t d			c ɟ	k g
Nasal	m		n			ɲ	ŋ
Tap or flap				r			
Fricatives		f v	θ ð	s z		ç ʝ	χ ɣ
Affricates				ts dz			
Approximant						j	
Lateral approximant				l		ʎ	

Consequently, not all of the sounds in the table are phonemic; some are simply allophones. The velar consonants [k,g,x,ɣ] are in complementary distribution with their palatal counterparts [c,ɟ,ç,ʝ] when one of the front vowels [i,e] or the approximant /j/ follows. The palatal nasal /ɲ/ and lateral /ʎ/ are also considered as allophones of /n/ and /l/ respectively, as they occur in specific environments; they precede an underlying /i/ or phonetically surfacing /j/. Lastly, the velar nasal /ŋ/ is an allophone of /n/, since it occurs when preceding a velar consonant, [k,g,x,ɣ].

Koutsoudas and Koutsoudas (1983) discussed the differences and similarities between the Greek and English phonological systems which are of relevance to the present study. All Greek vowels appear in all the environments, and their quality is unaffected by a lack of stress. In contrast, English vowels tend to be reduced in unstressed syllables. Moreover, the English vowel inventory for Standard Western Canadian English includes 10 monophthongal vowels (Andruski & Nearey, 1992; Nearey & Assmann, 1986) and thus allows far more distinctions than the five-membered Greek

one. It is particularly noteworthy that Hawks and Fourakis (1995) showed that [i,a,u] belong to the same phonological spaces as their American English counterparts, although Greek /e/ and /o/ overlap between the phonological spaces of English /e,ɛ/ and /o,ɔ/ respectively.

In regards to the consonants, the one difference that is crucial for the present study is the aspiration of the voiceless stops. Greek has short-lag unaspirated stops, while English has long-lag aspirated stops, as shown in Figures 1-1 and 1-2. In this study, the VOT values of Greek (Botinis et al., 2000; Fourakis, 1986) and English (Klatt, 1975; Lisker & Abramson, 1967) voiceless stops [p,t,k] are measured, as produced by Greek/English late bilinguals. In order for the reader to numerically understand the difference between Greek and English VOTs, the results of previous studies on Greek monolinguals and English monolinguals are presented in Table 1-3. Botinis' results were not included in the table, since that study examined only intervocalic voiceless stops before the vowel /o/.

Table 1-3: Greek and English Monolingual VOT Values in ms

Voiceless Stops	Greek	English	
	Fourakis	Klatt	Lisker
p	9	46.7	58
t	16	64.7	70
k	30	69.3	80

1.2 Theoretical Background/Previous Studies

1.2.1 Phonetic Acquisition by Greek/English Bilinguals

Based on the difference between Greek vs. English VOT, as previously presented, it is clear that a native Greek speaker has to adjust his or her stop production to authentically produce English voiceless stops. As shown in Table 1-3 and Figures 1-1 and 1-2, Greek /p/, /t/ and /k are short lag unaspirated, whereas in English, they are long lag aspirated at the beginning of stressed syllables. Therefore, Greek/English bilinguals need to modify their stop articulation by increasing VOTs so that they are as long as those of a native English speaker. Two theoretical proposals can offer insight in the phonetic acquisition of voiceless stops by Greek/English bilinguals. One of these is Best's Perceptual Assimilation Model (PAM), which is presented in subsection 1.2.2. However, the most relevant theory, on which this study is based, is the Speech Learning Model (SLM) by Flege, presented in subsection 1.2.3.

1.2.2 Perceptual Assimilation Model (PAM)

Best (1991, 1993a, 1993b, 1995) proposed the Perceptual Assimilation Model (PAM) to account for the discrimination of non-native sounds by adult speakers. PAM adopts a more psychological/developmental point of view of the phenomenon (adult-child differences). It mainly refers to perception and discrimination of non-native sounds, based always on the phonological space of the first language. However, the non-native sounds discussed are not necessarily sounds of the speaker's second language, but non-native sounds in general. In addition, PAM does not directly predict how the perception and discrimination of the sounds affects production.

According to PAM, a speaker tends to identify a non-native sound/phone in terms of his L1 sounds; in other words, to follow an assimilation process. Thus, two non-native phones can be perceived/identified as either:

a) a good match for two distinct native categories (TC=two category assimilation), b) a good assimilation of both to a single L1 phoneme (SC=single category assimilation), c) a better match for the one and a less good for the other to the same native phoneme (CG=Category Goodness) or d) non-assimilable, non speech sounds (NA). The possible pair combinations are Uncategorized-Categorized (UC) or Uncategorized-Uncategorized (UU).

Following PAM, the English long lag aspirated voiceless stops (/p/, /t/, /k/) might be perceived by Greek speakers learning English as a match to the corresponding categories for short lag Greek stop sounds. Thus, when learning English, a native speaker of Greek might assimilate English /p/, for example, to Greek short lag unaspirated /p/. All Greek voiceless stops are short lag, while phonetic categories are not differentiated based on aspiration. For L1, the features of place of articulation and voicing differentiate among categories. Thus, the long lag English /p/ would most likely be identified under the short lag Greek /p/ that has the same place of articulation. The same could be expected to happen for English long lag aspirated /t/ and /k/.

1.2.3 Speech Learning Model (SLM)

Flege and colleagues (Flege, 1987a, 1987b, 1991a, 1991b; Flege & Hammond, 1982; Flege et al., 2002; Flege et al., 2003) developed the Speech Learning Model (SLM) as an attempt to account for the common inability of late L2 learners to produce L2

sounds authentically. Accent is very common among late L2 learners and is considered to be a result of the "new wine in old bottles" phenomenon. With this expression, Flege refers to the fact that the knowledge of L1 crucially influences the acquisition of any L2 to the extent that L2 cannot be produced as it will be by a native speaker. L1 has been also compared to a first coat of paint: when another colour is applied on top of it, it does not turn out the same as the original because of the influence of the underlying colour, that is the influence of the first language in this metaphor.

Some of the hypotheses that have been proposed to explain this inability of late L2 learners refer to neurological maturation. It has been proposed that this maturation comes inevitably with age, reduces neural plasticity and thus, the ability to authentically produce the new sounds of L2. These hypotheses also are related to the Critical Period Hypothesis (CPH) (Flege et al., 1997). CPH suggests that after some particular age, usually placed at the end of adolescence, someone cannot learn a second language without having an accent. (Flege & Yeni-Komshian, 1999). However, Flege, Munro and MacKay's study (1995) showed that there is a gradient shift rather than an abrupt change in the L2 learners' ability to achieve native-like pronunciation of L2, as L2 learners get older - passing from childhood to adolescence. SLM attributes this difference between early and late bilinguals to inadequate phonetic input. It is not attributed to age or other phenomena that other hypotheses have suggested. These phenomena include the neurological changes that inevitably come with age; these maturational changes possibly affect the ability either to control the sensorimotor mechanisms and authentically produce new/L2 sounds or to create new phonetic representations and can also affect long-term memory. Also, attitudinal and psychosocial factors have been accused for accent such as

motivation, language aptitude/mimicry and amount of L1 use. (Flege et al., 1995; Flege et al., 1999; MacKay et al., 2001).

The postulates and basic hypotheses of SLM are discussed in detail in Flege (Flege, 1991b). With regard to SLM, speech production is organized at phonemic category, phonetic category and sensory-motor levels (Flege, 1991b, 1995). This results in late bilinguals identifying similar sounds under one phonetic category but still detecting acoustic differences between them, and then realizing the two sounds differently somehow by using different phonetic realization rules.

However, the most relevant part of the theory for the present study is the notion of equivalence classification. As introduced by Flege, equivalence classification exists in both L1 and L2 acquisition. In L1, a native speaker listens to many different instances of the same sound, but manages to categorize them as members of the same category. He or she overlooks the phonologically insignificant phonetic differences to perceive each instance as a realization of the specific L1 sound. It is likely that L2 learners use the same mechanisms, including equivalence classification that they used for L1 acquisition. However, in L2, the mechanism of equivalence classification may be seen as an impediment. It prevents L2 learners from categorizing under another category an L2 sound that is phonetically different in the L2 system, but not in the L1 system, where it is similar to an existing L1 sound. However, SLM (Flege, 1987, 1991, 1992) mentions that it is possible for a bilingual to perceive the differences between similar sounds, but instead of forming a new category in L2, over the years the bilinguals will form and use a new merged category including characteristics of both L1 and L2 relevant sounds. Thus, the result of this phonetic learning will be that the bilingual's production and perception

in L2 will still differ from those of monolinguals, but also his production and perception in L1 will gradually change to approximate L2 (MacKay et al., 2001).

Flege (1987b) taxonomized L2 sounds, as identified by an L2 learner, as 'identical, 'similar' and 'new' sounds/phones. 'Identical' is a sound such as English /i/ which is very close to the L1 Greek /i/ sound, so it would be subcategorized under the same L1 category. 'New" is a sound like French /y/ for English speakers, a sound that does not exist in the L1 phonetic inventory and differs significantly from any nearby sound in the L1 phonetic space) or similarly the Greek velar sound /ɣ/ for English speakers. 'Similar' sounds are ones that, even though they systematically differ acoustically and phonetically, are similar enough to use the same IPA symbol. This appears to be the case for the voiceless stops /p, t, k/ in Greek and English. They have the same places of articulation, bilabial, alveolar and velar respectively, but they differ with regard to the aspiration: in English they are long-lag aspirated, whereas in Greek they are short-lag unaspirated.

1.2.4 Similar/Previous Studies

A number of studies have examined the VOT of bilinguals, mostly focusing on languages where the difference is between short-lag versus long-lag VOT, such as the difference between Greek and English examined in this study. It will be useful for the present study to see what aspects of the phenomenon those studies looked at and what their results were.

Flege (1987b) studied English/French and French/English bilinguals in the production of /t/. The study showed that English/French bilinguals produced French /t/

with significantly longer VOT values than the French monolinguals, while French/English bilinguals produced English /t/ with significantly shorter VOT values than English monolinguals. The most experienced L2 speakers in both groups more closely approximated the values of the corresponding monolingual group, but again their VOT values differed significantly from those of monolinguals. Crucially, the study showed that both bilingual groups produced compromise VOT values for L2, that is, intermediate VOTs between the monolingual VOT values for L1 and L2. Flege also noted that experienced L2 learners seem to have created distinct phonetic categories for L2, while the less experienced L2 speakers produced different VOTs for L1 and L2 perhaps by applying different phonetic realization rules.

Flege (1991a) examined Spanish/English bilinguals' VOT in productions of /t/. They were separated into two groups of ten participants each; the ones who learned English in early childhood and the ones who learned English as adults. He also tested two control groups consisting of ten participants each; one for monolingual English and one for monolingual Spanish speakers. As expected, the short-lag VOT of Spanish monolinguals differed significantly from the long-lag VOT of English monolinguals. The results indicated that the early Spanish/English bilinguals' production of English /t/ did not differ significantly from English monolinguals' productions; their production of Spanish /t/ also did not differ significantly from Spanish monolinguals' productions. The late Spanish/English bilinguals produced Spanish /t/ with values that did not differ significantly from those of monolingual Spanish speakers. However, they produce significantly shorter English VOT values than monolingual English speakers did. Similar results were found in Flege, Frieda et al.'s study (1998) of Spanish/English bilinguals.

Also, Flege and Eefting (1986) compared the VOT values of English monolinguals producing Spanish /t/ with those of Spanish monolinguals, showing that the English bilinguals' values were significantly longer than those of Spanish monolinguals. Again, the conclusion drawn from those studies is that late bilinguals produce compromise VOT values and their VOTs in L1 appear to be affected because of L2 influence; that is, they are longer than the VOTs of monolingual Spanish speakers. Therefore, the proposal of a bidirectional interference (Flege & Davidian, 1985) is strengthened.

Flege et al. (1996) examined a large sample of 240 Italian/English bilinguals for their production of initial consonants; two of them were the voiceless stops /p/ and /t/. These bilinguals began learning English from 3 to 21 years of age and had an average stay in Canada of 30 years. Twenty-four native speakers of English living in Birmingham, Alabama, comprised the English control group. The results indicated that the bilinguals who came to Canada after 15 years of age produced /p/ and /t/ with significantly shorter VOT values than the native English speakers of the control group did. Even though the Age of Learning (AOL) English was an important factor, it was not the only determining one. A multiple regression analysis for VOT showed that the age of learning L2 accounted for 20% of the variability in the data, and language use factors accounted for an additional 10%, while 70% of the variance remained unaccounted for. The late L2 learners of this study again had compromise VOT values for English, and thus did not reach the target values exhibited by monolinguals. In addition, concerning the changes across the life span in learning ability, these studies showed that AOL and language related factors account for less than 50% of the variance in the data, thus more research is needed to identify the factors accounting for the rest of the variance and the

reason why age is negatively related to learning ability. The study questioned whether the bilinguals' accented speech was a result of their inability to detect the difference between L1 and L2 in VOTs, but this question needs further investigation.

In studies by Major (1990, 1992), motivation was investigated as a possible factor affecting VOT values. He interviewed five female adult English/Portuguese bilinguals who had reasons to retain proficiency in both languages. The participants were tested in both formal (words in isolation and original sentences) and casual speech (conversation). The results showed that their VOT values for English were significantly shorter and significantly longer for Portuguese than those of monolingual speakers. The loss of L1 which was estimated by comparing Formal and Casual English, expressed with the ratio For/Cas, was significantly correlated with the bilingual participants' mastery of Portuguese. It is significant that this study confirmed that even experienced and strongly motivated bilinguals in both languages produced intermediate VOT values for L2. In addition an influence on L1, expressed as Loss in Casual Speech was shown.

A study of twelve Arabic/English bilinguals (Flege & Port, 1981), who resided in the US from less than one year to over two years, showed that they produced English VOT with relatively shorter values than the American English monolinguals approximating the values for Arabic voiceless stops. They also had difficulty in producing /p/, since it is missing from the Arabic phonetic inventory, even though they showed a contrast between /p-b/ by making the closure interval longer. Again, the results of this study support the expectation that the bilinguals would produce intermediate VOT values and would also create a new category for the L2 sound /p/.

Kim (1994) analyzed French and Korean voiceless stops in continuous speech, based on VOT values. Native French speakers produced French stimuli, while Korean/French bilinguals produced both French and Korean stimuli. The study concluded that the bilingual Korean/French speakers realized a new category with intermediate values for the French stops. Again, the bilinguals having Korean as L1, which has long-lag VOTs, produced L2 VOTs with intermediate VOT values, that is, shorter than L1 but longer than L2.

Flege and Eefting (1987) worked on the distinction of aspirated vs. non-aspirated voiceless stops for English and Dutch respectively. The Dutch participants were not bilinguals, as in the studies mentioned before, but they had studied English. Specifically, the results of a perceptual continuous scale identification test from /t-d/ showed that Dutch speakers of English produced English VOT values with values longer than those of English monolinguals, while the more proficient Dutch speakers of English produced more English-like VOT values. This study's result is important since it refers to a long-lag (English) versus short-lag (Dutch) comparison such as the comparison between Greek and English. It showed that L2 proficiency did not change the boundary shift in the identification test, while both less and more experienced Dutch speakers of English fail to reach monolingual English VOT values.

Wang and Behne's (2007) study examined stop-vowel syllables as produced by Mandarin/English bilinguals in both Mandarin and English; also, two control groups of monolingual Mandarin and English speakers were examined. The temporal measures examined were stop closure duration, VOT, vowel duration and syllable duration. Mandarin has both aspirated and unaspirated voiceless stops, but no voiced stops. The

results that are of interest for this study are those concerning VOT productions of voiceless stops by Mandarin/English bilinguals. VOT of aspirated voiceless stops differed significantly among the three groups, while VOT of unaspirated voiceless stops did not. Mandarin VOT values are longer than VOTs of English aspirated voiceless stops, but the bilinguals produced values shorter than those of both Mandarin and English monolinguals. The study overall supports the interlanguage concept, since the bilinguals did not directly substitute stop sounds from L1 to L2. On the contrary, the bilinguals in all temporal features examined showed stable patterns in their production that differ from both languages.

To sum up, based on the results of the previous studies, several predictions can be made. First, it can be expected that Greek/English speakers will produce English voiceless stops with VOT values intermediate between those of Greek and English. Second, AOL is likely be an important factor affecting VOT values. Third, late bilinguals will probably distinguish between Greek and English homorganic stops. Fourth, it can be expected than bilinguals' Greek (L1) VOT values will be longer than Greek monolinguals' VOTs because of an L2 influence.

An interesting theoretical problem arises from the previous studies that remains unanswered. Flege argues that late bilinguals sometimes produce significantly different VOT values for L1 and L2 as a result of applying different phonetic realization rules to the same category. However, he has not proved wrong the hypothesis that bilinguals' productions are a result of creating distinct phonetic categories for L2. If bilinguals do create distinct categories regardless of age, then the question raised is why do late bilinguals and early bilinguals differ in their ability to realize these categories? According

to Flege, late bilinguals fail to authentically realize these categories, while early bilinguals succeed. If late bilinguals create new categories, that means that they perceive the sounds equally well as the early learners, but still do not produce them authentically. In other words, this inability of late learners could be due to motoric difficulties that affect singular production.

1.2.5 Studies of Accented Speech

The phenomenon of accent is very common among L2 learners who have learned their L2 after early childhood. What is described as an accent consists of segmental and non-segmental phenomena; the latter includes not only prosodic differences from L2 norms, but also differences in stress, intonation, speaking rate and voice quality (Flege et al., 1995; Munro & Derwing, 1995; Munro et al., 2006). Native L2 speakers are sensitive to accented speech and can identify it as easily as they identify cross-dialectal differences within L2. A small speech token, even a word or a segment, is enough for a native L2 speaker to understand that a speaker has a non-native linguistic background, or even the specific background (Flege, 1984). Even when speech is presented backwards, a native speaker is able to identify an accent (Munro et al., 2003). This may be because the listener's judgment is based on the speaker's voice quality (Esling & Wong, 1983). Also, it is common that native L2 speakers unexposed to accented L2 speech show impatience, difficulty in understanding the speech of an inexperienced accent or even prejudice; they often tend to downgrade a L2 speaker's education or intelligence because of his/her foreign-accented speech (Albrechtsen et al., 1980; Anisfeld et al., 1962; Brennan & Brennan, 1981a, 1981b; Cunningham-Anderson, 1993; Fayer & Krasinski, 1987; Gumperz, 1982; Gynan, 1985; Johansson, 1978; Kalin & Rayko, 1978; Lippi-Green,

1997; Sato, 1991). In other words, the linguistic phenomenon of accent is "coloured" with socio-political judgements and consequences for the listeners and speakers. That is the reason why, in countries such as Canada, legal action has been taken against accent discrimination (Munro, 2003), while testimonies of L2 learners confirm the socio-political aspect of accent (Derwing, 2003).

Some studies focusing on accent and VOT are discussed below. Their research questions and results are valuable for the present study to consider. As mentioned above, Flege, Munro and McKay (Flege et al., 1995) examined 240 Italian/English bilinguals in the production of a number of English sentences. The bilinguals' age of learning (AOL) varied from 3.1 to 23 years of age, while they had lived in Canada for an average of 35 years. Native speakers of English using a continuous scale rated their sentence production for degree of accentedness. The results showed that AOL accounted for 59% of variance and other language factors accounted for an additional 15% of variance. Gender also played a role in the degree of accent, since AOL accounted for more variance for female than male speakers did. The main conclusion of the study was that there was a gradual decline in ratings due to an AOL effect and not a precipitous one, for example after the age of 15, as had been previously suggested (Patkowski, 1990). In the present study, it will be interesting to see whether the AOLs of Greek/English bilinguals will also strongly influence their accent.

Alba-Salas (2004) conducted a perception experiment with two groups of native English speakers; one group had a good to excellent knowledge of Spanish and the other included monolingual English speakers with no knowledge of Spanish. The listeners were asked to identify the linguistic background of the speakers-if their accent was Romance,

specifically Spanish or something else. The stimuli consisted of words viewed on a PC, while the listeners heard recordings of the initial stop consonant. The native speakers of Spanish and those of English with Spanish as L2 identified correctly the background of the speakers, while the monolingual English speakers appeared to be less successful in their judgments. The results showed a moderate positive correlation between VOT and accent. It will be interesting to see whether the results from Greek/English bilinguals in the present study will show a similar correlation.

There are many studies examining the effect of different factors on foreign accent. For example, a study of 30 Quicha/Spanish bilinguals by Guion, Flege and Loftin (2000) tested the production of Quicha (L1) and Spanish (L2) sentences and their degree of foreign accent. The results indicated that the higher the L1 use, the stronger the accent perceived in L2 was, while the amount of L1 use did not prove to affect L1 production. The writers also referred to a similar experiment on 240 Korean/English bilinguals (Yeni-Komshian et al., 2000) that showed that degree of accentedness in L1 and L2 are inversely correlated; in other words, the better a bilingual pronounced Korean, the worse he or she pronounced English. Based on the above results, it can be expected that the higher use of Greek will result in a stronger accent in English for Greek/English bilinguals.

In Flege, Yeni-Komshian et al. (1999) 240 Korean/English bilingual speakers with different AOA (Age of arrival to L2-speaking environment) produced some English sentences that were rated on a 9-point scale for degree of foreign accent. The results proved that later AOAs-even when the other variables were kept the same, coincided with a stronger degree of accent. The linear/ gradient relation between the accent ratings and

the AOA does not support the idea that there is a critical period after which it is impossible for a L2 learner to produce L2 with native-like authenticity.

In Flege, Frieda, at al (1997) a series of English sentences produced by Italian/English bilinguals with different AOA and self reported use of Italian were rated for accentedness by a group of native English speakers. The results showed that AOA accounts for 13% of the variance, while the self reported use of Italian accounts for another 9%.Thus, the bilinguals that spoke Italian relatively often (15-60%) had significantly stronger foreign accents than those who seldom used Italian (0-5%).

The present study examined the degree of accentedness in the English speech of 20 late Greek/English bilinguals, as represented by the reading of three sentences. The purpose of this experiment was to see whether VOT values and accent are related and to identify learner's characteristics that influence strength of accent. The studies outlined above are pertinent to the present study, because they highlight various factors that influence accent, and they show how accent and speech production such as VOT values are related. According to the previous studies, AOL is the single most influential factor on accent, followed by AOA (Flege et al., 1997; Flege et al., 1999). Also, strength of accent positively correlates with amount of L1 use and negatively correlates with L1 accent (Guion et al., 2000). Lastly, Alba-Salas (2004) showed a moderate positive correlation of Spanish speakers' foreign accent with their English VOT.

1.2.6 Hypotheses and Research Questions

After reviewing the existing relevant literature, some basic hypotheses can be formed to facilitate the study of VOT and accented speech produced by Greek/English bilingual participants. These hypotheses can be stated as follows:

H1: The Greek/English bilinguals will produce intermediate VOT values for English stop consonants in word initial position: values longer than Greek VOT values, but not as long as those of monolingual English speakers. This hypothesis is based on the SLM's predictions and the results of studies such as on Quicha/Spanish (Guion et al., 2000), on Spanish/English (Flege, 1991a, 1991b; Flege et al., 1998), and on Italian/English bilinguals (Flege et al., 1996).

H2: The Greek/English bilinguals will produce longer VOT values for Greek voiceless stop consonants than do typical monolingual Greek speakers, because of the long-term influence of English/L2. This hypothesis is based on the SLM's predictions and the results of studies such as on Quicha/Spanish (Guion et al., 2000) and on English/Portuguese bilinguals (Major, 1990, 1992).

H3: On the basis of studies such as Alba-Salas (2004) on English and Spanish, it is expected that the degree of foreign Greek accent of the bilinguals will correlate with their English VOT values. In particular, shorter VOT values will be associated with stronger perceived accents in English.

H4: The degree of Greek foreign accent of the bilinguals will correlate with their AOA; in other words, the younger a participant was on arriving in Canada; the less accent he or she is expected to display. This hypothesis is based on the SLM's predictions and the results of such studies as done by Flege, Yeni-Komshian & Liu (1999).

To test the hypotheses that have been proposed above, it will be necessary to answer the following questions that will guide the research:

1. Do the bilinguals produce different VOT values for the two language systems? If yes, is this phenomenon observed in all vowel environments?

2. Do any of the factors such as AOA, education level in Greek, education level in English, LOR, proficiency in Greek, proficiency in English, or L1 use predict the English VOT values?

3. Do any of the factors such as AOA, education level in Greek, education level in English, LOR, proficiency in Greek, proficiency in English, or L1 use predict the Greek VOT values?

4. Do any of the factors such as AOA, education level in Greek, education level in English, LOR, proficiency in Greek, proficiency in English, L1 use, or gender correlate with degree of Greek foreign accent?

CHAPTER 2:Methodology

The methodology in this research follows that of similar studies such as Klatt (1975), Fourakis (1986), Flege, Munro and MacKay (1995). This chapter is structured as follows: section 2.1 discusses the criteria according to which the participants were recruited. It also includes the information obtained from the participants who completed a language background questionnaire (LBQ). Section 2.2. refers to the stimuli used in this study. This included a series of Greek and English words and three English sentences that the participants were asked to read. Section 2.3 is a description of the procedures followed for the data collection. Section 2.4 presents the criteria used for the analysis, in this case, for the VOT and vowel measurements. The last section, 2.5, is devoted to the accentedness experiment. Four native speakers of English for degree of accentedness rated the English sentences that the participants read. Information concerning the listeners and the procedures followed is listed in this section.

2.1 Participants

The target of this study was to examine stop production in late Greek/English bilinguals who reside in the Greater Vancouver area, British Columbia, Canada. There were 21 participants recruited on the basis of personal contact and acquaintances, members of the Greek Community of the Lower Mainland of Vancouver. They reported no knowledge of languages other than Greek and English. Only two participants had a knowledge of French; the first one had a basic knowledge, since he had lived for a while

in Montreal, while the second one had a very good knowledge, since he had completed college studies in Belgium and had also lived in Montreal for a period of time.

One participant was excluded, since he did not meet the criteria as a late Greek/English bilingual. According to his answers in the LBQ, he had been exposed to both languages during early childhood. When he arrived in Canada, he started learning English at the age of 6 years; he then returned to Greece when he was 11 years old. It could not be established that Greek was his first language (L1), but he was more of a balanced bilingual, as the accentedness experiment results also supported.

Table 2-1: Characteristics of the Bilingual Participants

SJ#	Region	Age	AOA	AOL	LOR	EdG	EdE	PG	PE	%Use	Gender
G1	Kefalonia	65	27	20	38	BA	IDA	4	3	40	M
G2	Larissa	62	20	20	42	Col	BA	5	5	20	F
G3	Kalamata	71	25	17	46	Hs	Col	4	3	90	M
G4	Lesvos	39	23	16	16	BSc	Uni C	5	4	60	M
G5	Athens	39	21	4	18	BSc	MA	5	5	40	M
G6	Alexandroupolis	42	25	10	17	Hs	BA	5	5	15	M
G7	Piraeus	57	24	12	33	Col	---	3	4	50	F
G9	Athens	55	27	28	28	Hs	Hs	4	3	80	F
G10	Nemea	68	18	18	50	Hs	Hs	4	4	60	M
G11	Athens	57	19	14	38	Hs	Col	5	5	60	F
G12	Athens	62	23	23	39	Hs	Col	5	5	40	M
G13	Kefalonia	60	27	15	33	BA	Col	5	5	0.5	F
G14	Athens	55	22	14	33	Hs	Col	4	4	50	F
G15	Karditsa	64	19	19	45	Hs	Col	4	3	60	M
G16	Athens	65	27	27	38	E	--	4	2	95	M
G17	Athens	57	19	19	38	E	--	5	3	95	F
G18	Aigeira	52	17	14	35	Hs	Col	4	4	30	F
G19	Athens	61	32	16	29	Hs	Uni C	5	5	80	M
G20	Amaliada	54	15	13	39	I Hs	Col	4	4	70	F
G21	Kefalonia	78	29	20	49	BA	BA/LLB	5	5	10	M
	Average	58.2	23	17	35.2			4.5	4.1	52.3	

Notes: SJ#: Participant #; Region= The place that a subject was born and grew up. If the birthplace was different, it is the place where the subject grew up; EdG= Education acquired in Greek; EdE= Education acquired in English; LOR= Length of residence in Vancouver/English-speaking Canada in years; AOA= Age of arrival; AOL= Age of learning; %Use= Percentage of weekly use of Greek; PE= Self-rated proficiency in English, scale 1=low proficiency to 5=high proficiency; PG= Self-rated proficiency in Greek, same scale (1-5); IDA= training courses in business; Col= college; Hs= high school; Uni C= university courses; E= elementary; 1 Hs= high school, but the subject did not finish the last two grades of high school

As summarized in Table 2-1, the 20 participants included in this study were all born in Greece and immigrated to English-speaking Canada when they were at least 16 years of age (average age of arrival (AOA)=23, range=16-32). The sample included 11 male and 9 female bilingual speakers. Their average length of residence (LOR) was 35.2 years, (range=16-50 years). As Flege noticed in his studies, LOR and AOA are related; in this case, the earlier someone came to Canada, the longer he or she was in the country. This was true for the majority of my sample. It must be mentioned that participants G4, G5, G6 spent fewer years in Canada, even though they came at a younger age compared to the others. This is simply because they were the youngest at the time of the interview. The only exception was subject G19, who came to Canada at the age of 32 and whose LOR is 29 years.

The mean age of the participants when they were tested was 58.2 years, (range=39-78 years). They started learning English at an average age of 17 (AOL), (range 4-28). However, AOL will be considered only supplementarily to AOA, since these two usually coincide. In this sample, AOA differs from AOL by as little as 0 and as much as 17 years. Six of the participants reported 0 years difference. In other words, they started learning English when they arrived in Canada. Nine participants reported less than 9 years difference, while the rest had 12 to 17 years of difference. This last group included the youngest participants. The majority of the participants, with the exception of G4, G5, G6, G7 and G19 stated that their knowledge of English before arriving in Canada was restricted to basic grammar and communication skills, and consider their real age of learning of English to be their age of arrival (AOA) in Canada (see similar remarks in Flege et al., 1999, 2001, 2003).

The participants' highest education level in Greek varied from elementary school to a bachelor's degree. Thus, all participants had received a good foundation in Standard Modern Greek (SMG). To summarize, 7 participants had a higher education (college or university degree), 11 had a secondary education (high school) and 2 had an elementary education. Their highest education level in English varied from no education at all, to a master's degree. Fifteen participants had a higher education (college, university diploma or courses and one had a master's), 2 had a secondary education (high school/ESL courses) and 3 had no official education in English at all; these participants had moved straight into the workforce when they immigrated to Canada.

The participants were asked to estimate their proficiency in Greek and in English using a 5-point scale, with 1 being the lowest/basic proficiency to 5 being the highest proficiency. The highest proficiency means that the participant is fluent in everyday written and spoken English or Greek. The results indicated an average self-estimated proficiency in Greek of 4.5, (range=3-5) and an average self-estimated proficiency in English of 4.1, (range=3-5). Thus, the participants in this study generally thought of themselves as being proficient in both Greek and English.

With regard to the use of L1/Greek, the participants were asked to estimate, based on percentage, their overall weekly use of Greek. The average percentage given was 52.3%, with a range of 0.5% to 95%. Obviously, it is difficult for a participant to give an exact percentage of his/her L1 use. For this reason, the participants were also asked to give an estimated percentage of L1 use for each day of the week and separately for each of the domains of family, job and friends. The results are shown in Table 5.1 in Appendix 2. These supplementary results, when taken together, support the overall estimated

percentage that the participants gave. For example, one participant reported using Greek 20% of the time during an average week. This same participant also indicated a percentage of 16% use of Greek in the family domain, 2.5% with friends and 0% at work. Thus, the overall percentage of 20% appears to be a trustworthy figure.

In discussing the places of origin of the participants, the dialectal differences in Greece must be taken into consideration. Nine participants were born and raised in Athens, the capital of Greece where SMG is spoken, while 7 originated from different areas of Peloponnesus and of the Ionian Islands. These dialects have minimal differences with SMG, since SMG was based on them (Browning, 1983; Holton et al., 2004). Only four participants originated from other places: one from the island of Lesvos, one from Alexandroupolis, in the north-east borders of Greece and two from Larissa in the centre of Greece (See map of Greece in Appendix 3). However, the researcher, a speaker of SMG, based on the conversations with all the participants, established that they spoke SMG. According to Mackridge (1987), educated people know the standard. Moreover, the author is unaware of any research mentioning differences in VOT among the main Greek dialects (Andriotis, 2003; Kontosopoulos, 1994).

COMPARISON GROUP: A group of three Greek participants was interviewed for comparison purposes. They were Greek/English bilinguals but they had been exposed to English for a shorter period of time than the other bilingual participants of this study. Henceforth, they will be referred as short-term residency Greek participants. Except for the pilot studies of Fourakis (1986) and Botinis et al. (2000), there is no study examining Greek VOT. However, Fourakis' participants were bilinguals too, since they were all

students at Iowa university (personal communication, 29th August 2006), while Botinis examined Greek VOT only before the vowel /o/.

Therefore, to permit a reliable comparison with the previous studies and a reliable estimate of the Greek VOT values, the researcher interviewed these three participants. They were speakers of SMG, but not monolinguals, since they all have a good knowledge of English. However, they differed from the test group in that they were short-term residents of Vancouver, BC; they had recently come from Greece. Their LOR ranged from 6 months to 4 years (average=2.5 years) and they all practiced professions demanding a high use of Greek (average=73.3%, range=60-90%). Their average age was 39.3 (range 25-50). Personal data on the participants can be seen in Table 2-2.

Table 2-2: Characteristics of the Short-term Residency Greek Participants

SJ#	Region	Age	AOA	AOL	LOR	EdG	EdE	PG	PE	%Use	Gender
G0	Aigio	50	49	13	1/2	BA	---	5	3	90	M
G0f	Athens	25	22	12	3	BA	MA	5	4	60	F
G0f2	Patra	43	39	6	4	BA	---	5	4	70	F
	AVERAGE	39.3	36.7	10.3	2.5			5	3.7	73.3	

2.2 Material

The test material consisted of a series of Greek and English words, plus three English sentences. The Greek stimuli were 15 Greek disyllabic words, of which both syllables were of CV (consonant-vowel) structure. All the words were initially stressed. The first consonant varied over the three voiceless stops (p, t, k) and the following vowel over the 5 Greek vowels (/i/, /e/, /o/, /u/, /a/). Hence, all the VOTs measured in this study were in word-initial stressed syllables. There were also 5 distractors, polysyllabic

Greek words used to randomize the stimuli and 'distract' the participants from the main focus of the study, VOT. The Greek stimuli are presented in Standard Greek orthography and in IPA transcription in Table 2-3:

Table 2-3: Greek Stimuli

Greek Orthography	IPA transcription	Translation
κοίτα	'kita	look (present, 2nd sg)
κέφι	'kefi	gaiety, good spirits
κάτω	'kato	down
κότα	'kota	chicken
κούτα	'kuta	box
πίνω	'pino	drink (present,1st, sg)
παίζω	'pezo	play (present,1st, sg)
πάμε	'pame	let's go (present,1st, pl)
πότε	'pote	when
πούντα	'puda	(catch) a cold
τύχη	'tixi	(good) luck
Τέμπη	'tebi	Tebi, a valley in Greece
τάμα	'tama	(religious) offering
τότε	'tote	then
τούμπα	'tuba	somersault
DISTRACTORS		
πακέτο	pa'keto	package
ακόμη	a'komi	yet
καπέλο	ka'pelo	hat
πατέρας	pa'teras	father
γατούλα	ya'tula	kitty

Even though the real Greek words were selected to be of CVCV structure, the recordings showed a different structure for some of the words. For the words (/'puda/, /'tuba/, /'tebi/), during the data analysis it was found that there is an alternation between the versions mentioned and the prenasalized versions /'punda/, /'tumba/ and /'tembi/

(Arvaniti & Joseph, 1999; Malikouti-Drachman, 2001). Some speakers used the first form while some used the second.

The English stimuli were 15 English disyllabic words of which only the first syllable was of CV structure. It was not possible to find real English disyllabic words beginning with a voiceless stop with both syllables of CV structure for all the combinations of voiceless stops and vowels in the first syllable. For example, the word /'toni/ is of CVCV structure. However, in other stimuli, the second syllable is of CVC structure, i.e /'pinʌt/ or of CCVC, i.e. /'tispun/. The first syllable of the words was stressed and started with a voiceless stop. The vowel of the first syllable varied over /æ/, /ɛ/, /o/, /i/, /u/, vowels of the closest possible quality to the 5 Greek vowels. Henceforth, for simplicity I use the names of the closest equivalent 5 Greek vowels. Also, 5 polysyllabic English words/distractors were used. The English stimuli are presented in Standard English orthography and in broad IPA transcription in Table 2-4.

Table 2-4: English Stimuli

English orthography	IPA transcription
peanut	'pinʌt
pedal	'pɛdəl/'pɛdl̩
passion	'pæʃən
poker	'pokəɹ
pooling	'pulɪŋ
teaspoon	'tispun
tenant	'tɛnənt
tanning	'tæniŋ
Tony	'toni
toonie	'tuni
keeper	'kipəɹ
kettle	'kɛtəl/'kɛtl̩/'kɛɾəl
caption	'kæpʃən
coping	'kopɪŋ
cooler	'kuləɹ
DISTRACTORS	
police	pə'lis
potato	pə'teto
catastrophe	kə'tæstɹəfi
territory	'tɛɹətoɹi
kangaroo	kæŋgə'ɹu

The sentence material used in this study included the following sentences: 1) The Queen of England lives in London. 2) Some people love to eat chocolate. 3) Ships travel on the water. They were taken from Munro and Derwing (1995). The sentences were chosen so as to include a good representation of the English phonological inventory and instances of the three voiceless stops examined in this study. Also, they included phones that distinguish Greek from English and thus appear to be difficult for native Greek speakers to produce authentically, such as /ɪ/ and /ʃ/, in 'ships', /w/ in 'water' or /ts/ in 'chocolate'.

2.3 Procedures

The participants, both the Greek/English bilinguals and the three short-term residency Greek participants, were recorded individually in the quietest room available in each participant's house. The interviews were conducted mainly in Greek by the researcher, who is a native speaker of SMG. This was done so that the participants would feel more comfortable. However, when a participant occasionally shifted to English, the researcher would also follow by speaking in English.

The recordings were made with a professional quality portable cassette tape recorder (Sony VM-D6C, Stereo Cassette Corder) using a directional head-mounted microphone (Optimus Headset Microphone, 33-3012) positioned about six inches from the participant's mouth.

The procedures were carried out in the following order: After the participants were generally informed that the study deals with bilingualism, they signed the consent form. Then they completed a language background questionnaire (LBQ), a copy of which can be seen in Appendix 1. The participants were instructed to read the words and the sentences at their normal speaking rate, trying to maintain a constant speaking rate and loudness level.

The participants' first task was to read the Greek stimuli in a carrier phrase, "Ipa____'pali' "(I) said___again". In the second task, they were asked to read the English words in the carrier phrase "I say__again". For both tasks, there were three repetitions of each item, and the words were typed on 5x3 inch cards in Standard Greek orthography and in English orthography, respectively. The researcher randomized the stimuli before

giving them to a participant to perform the tasks. Thereby, each participant produced the stimuli in a different order.

In the third task, the participants read the three English sentences, repeating each three times. The sentences were not designed to be particularly difficult for Greek speakers of English. The sentences were presented in written form, in Standard English orthography on a laminated page.

In all three tasks, the participants were asked to first review the words and sentences to ensure that they were familiar with them and to give them an opportunity to practice reading them. All participants skimmed through the stimuli, and nobody asked for assistance. Three tokens of each sentence were elicited. Also, at the end of each task, the researcher asked them to repeat any stimuli that were not pronounced fluently. After the interview was over, a more detailed debriefing concerning the focus of the study, bilingualism, VOT and foreign accent was given to the participants.

2.4 VOT Measurements

The recordings were digitized at 44.1KHz with 16-bit resolution. Praat 4.3.04 (Boersma & Weenink, 2006) was used for the analysis of the sound files collected. Two acoustic measurements were made from the digitized waveform of each word; VOT and vowel duration. The measurement criteria used are in agreement with those used by Flege (1987b), Klatt (1975) and Fourakis (1986).Voice onset time was measured to the nearest 0.1 ms from a combined display of the waveform and a broad-band spectrogram by positioning a left cursor at the beginning of the sharp increase in energy signalling the release of a voiceless stop. On the right side, the cursor was placed at the first upward

zero-crossing, after which the periodicity signalling the vowel's onset started. In the broad-band spectrograms used, the release of the stop can be identified as a burst of frication noise following the closure interval, while the voice onset time's ending is signalled by the periodicity produced by the laryngeal movements for the vowel production as the vowel formants begin to show definition. More on the difficulties and problems faced in VOT measurements are discussed in Lisker and Abramson (1964, 1967). With reference to the measurement of the vowel duration, it was measured from the end of VOT to the end of the vowel formants (mainly F2).

Analyzing the data, the researcher came across a number of instances of double or multiple burst consonants. The phenomenon was treated according to Herbst's (2005) solution based on Turk et al. (under review). Following their recommendations, the first burst was measured as the first obvious articulatory movement (jaw or tongue) in the articulation of the stop. The following burst(s) is thought to be a result of the Bernoulli effect and "the narrow aperture between tongue and palate, so that these releases are probably not actively controlled." (Herbst, 2005: 16). The first burst was not used, but the second one instead, only in cases where there was 20 ms or more silence between the bursts. There were only 10 cases overall in the data collected (5 in English and 5 in Greek) and 3 for the data by the short-term residency Greek participants (2 in English and 1 in Greek).

In the data collected there were tokens that unfortunately had background noise or microphone reverberations within the area of interest. This problem was addressed as follows: when the noise was short and either inside the vowel or in the VOT and vowel border, the token was used for VOT and vowel measurements. However, when the noise

was inside the VOT, obscuring its duration, the whole token was treated as missing. A total of 37 items out of 1800 were excluded for this reason; this equals a percentage of 2.1% missing data.

Thus, the VOT tokens collected for Greek were [20 x 15 x 3-15]= 885 (missing data= 1.6%) and for English [20 x 15 x 3-22]= 878 (missing data= 2.4%). The vowel token collected were the same in number. With reference only to the 'comparison group', the VOT collected were [3 x 3 x 15]= 135 for Greek (0% missing data) and [3 x 3 x 15-1]= 134 for English (7.4% missing data).

2.5 Accentedness Experiment/Listeners

The sentences produced by the participants were digitized at 44.1 KHz with 16-bit resolution and then normalized for peak amplitude to ensure a constant presentation volume. The researcher scanned the sentences for overall quality, selecting three from each subject. For each participant, one fluently produced token was selected from the three produced for each sentence. Thus, the stimuli for the accentedness experiment were [24 x 3= 72] sentences to be rated for accentedness. A custom-designed playback program was used to randomly present the stimuli and collect the responses.

Four listeners individually rated the sentences in a sound-treated booth, where the stimuli were presented via headphones. They were all native speakers of Standard Western Canadian English, experienced linguists, two male and two female, with a minimal contact with people who spoke English with a foreign Greek accent. All had passed a pure-tone hearing screen. Their average age was 40.3 (the ages of the four listeners were 26, 27, 49 and 59). They used a 9-point scale ranging from 1 "no accent" to

9 "the strongest accent/extremely strong accent". They initially practiced by rating 10-12 sentences, and after they were familiar with the procedure, the sound level, and the samples, they rated the sentences for accentedness three times each. The stimuli were randomized for each of the three times that each judge listened to them. Before starting the experiment, the following paragraph was read to them as instructions:

"You will hear a number of sentences from people, most of whom have an accent. We want you to assign a rating indicating how strong the accent of the speaker is. You will use a 9-point scale, where 1 equals no accent and 9 equals the strongest accent/extremely strong accent. Please use all the numbers of the scale between the two extremes to rate the different degrees of accent. It is a self-paced task. So, when you are ready, press OK to start practicing-the first 12 sentences will be just for practice. If your answer does not register, click it again. You will perform the task three times."

CHAPTER 3: Data Presentation and Analysis

3.1 Analysis of VOT Data

3.1.1 Greek VOT Data

The Greek data can be described based on the following figures. The data were pooled over speakers to compute mean VOT values for each consonant, each vowel and each consonant+vowel combination. Figure 3-1 illustrates the results for the VOT values of the three voiceless stops in Greek. The figure shows that the VOT values for /p/ are shorter than for /t/ and for /k/, which has the longest VOT values.

Figure 3-1: VOT of Greek Voiceless Stops with Standard Deviations

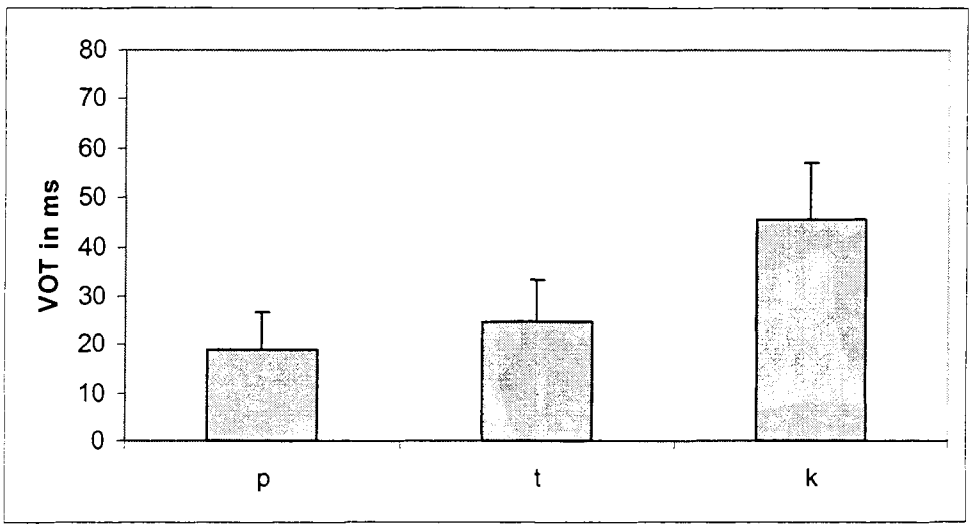


Figure 3-2 shows the overall VOT values for all the voiceless stop consonants together in front of each of the five vowels. It is evident that a high vowel environment,

that is /i/ or /u/, results in longer VOT values, although the mid vowel /o/ is not far behind.

Figure 3-2: Mean VOT in front of the Five Greek Vowels

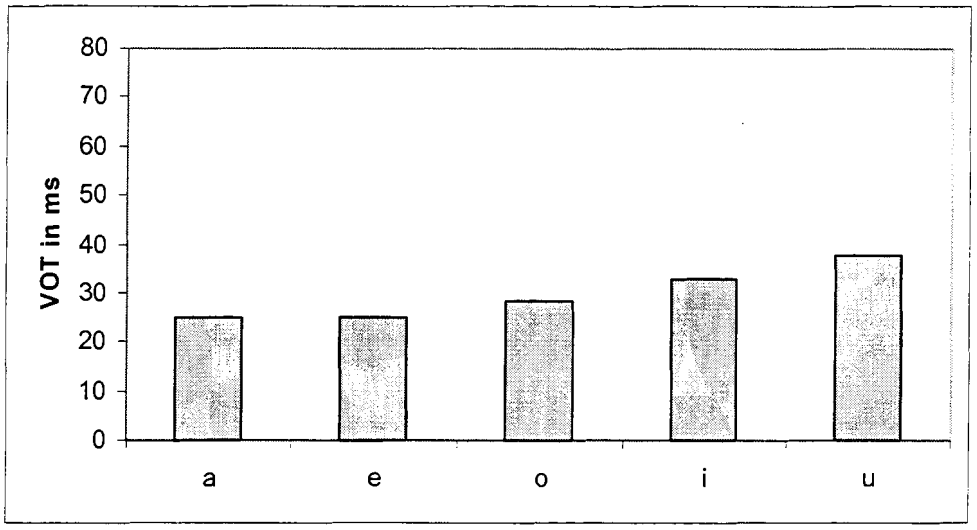
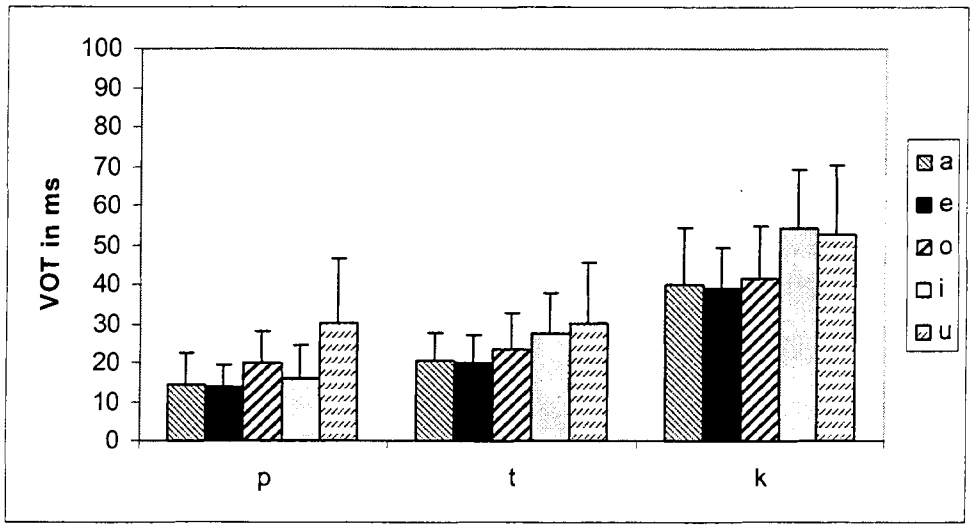


Figure 3-3, presenting VOT values of each stop in front of each vowel, offers a more detailed insight into the results. The figure suggests that /k/ is affected by a high-vowel environment (i, u), resulting in longer VOT values, as is /t/. However, /p/ has longer VOT in front of /u/, but not /i/, while the second longest values are before /o/. Also, the figure shows that the VOT values of the three stops do not differ much when /a/ or /e/ follows.

Figure 3-3: VOT for each Greek Stop in front of the Five Vowels with Standard Deviations



The VOT data were analyzed within each language and across the two languages. For the Greek data, a two-way repeated measures analysis of variance (ANOVA) was carried out. The factors examined were Consonant (3 levels: p, t, k) and Vowel (5 levels: a, e, i, o, u). The ANOVA yielded a significant effect of Consonant [$F(2,38)=117.41$, $p<.001$] and Vowel [$F(4,76)=21.87$, $p<.001$], as well as a significant Consonant x Vowel interaction [$F(8,152)=5.08$, $p<.001$].

Post-hoc tests were implemented to discover the source of the interaction between consonant and vowel. Two series of Bonferroni-adjusted paired *t*-tests were computed. The first series examined each consonant over the five vowels. For /p/, the tests revealed that VOT for /pu/ was significantly longer than for all other p+vowel combinations ($p<.001$, except for /po/ at $p<.05$), and the VOT for /po/ was significantly longer than for /pe/ ($p<.05$). For /t/, the tests indicated that VOT for /ti/ and /tu/ were significantly longer than for /ta/ and /te/ ($p<.05$). However, the VOT for /tu/ and /ti/, the t+ high vowel combinations, did not differ significantly from each other. Also, the VOT for /to/ did not

differ significantly from any other t+vowel combination. For /k/, the VOTs for /ki/ and /ku/, the k+high vowel combinations, were found to be significantly longer than the VOT for any other k+vowel combination. The VOT for the k+high vowel combinations (/ki, /ku/) did not differ significantly from each other.

To summarize, the combinations of voiceless stops+high vowels sometimes, but not always, resulted in longer VOT values, as previously shown by Fourakis (1986). However, /p/ shows longer VOT values only in front of /u/, but not /i/. A "high vowel" effect has been also observed in English produced by monolinguals (Klatt, 1973, 1975; Port & Rotunno, 1999) and bilinguals (Flege et al., 1998).

The second series of *t*-tests examined the differences in VOT between the possible pairs of consonants before each vowel. The results of these comparisons are presented in Table 3-1. It can be seen that most comparisons yielded a significant difference. Overall, VOTs for /p/ were shorter than for /t/, which in turn were shorter than for /k/. This is true for all voiceless stop+vowel combinations, except for the pair /po/ and /to/, as well as /pu/ and /tu/, which did not differ significantly in VOT values. Thus, the general tendency for /p/ to have shorter VOT values than /t/ was not observed when the following vowel was /o/ or /u/. On the other hand, VOTs for /k/ were always significantly longer than for both /p/ and /t/.

Table 3-1: Results of VOT Comparisons for Greek Stop+Vowel Combinations

Comparison pairs	Significance (Bonferroni-adjusted)
pa<ta	.05
pa<ka	.0001
ta<ka	.0001
pe<te	.05
pe<ke	.0001
te<ke	.0001
po<to	**NS**
po< ko	.0001
to<ko	.0001
pi<ti	.0001
pi<ki	.0001
ti<ki	.0001
pu>tu	**NS**
pu<ku	.0001
tu<ku	.0001

To sum up, the significant Consonant x Vowel interaction can be attributed to two phenomena: a) /t/ and /k/ showed longer VOT values before the high vowels, /i/ and /u/; however, /p/ had a longer VOT when /u/ followed, but not when /i/ followed, and b) VOTs for /p/ tended to be shorter than for /t/, which always had shorter VOTs than /k/; however, /p/ and /t/ did not show significantly different VOT values, when /o/ and /u/ followed.

3.1.2 English VOT Data

To give an overview of the results for the English VOT values, the following three figures are presented. Figure 3-4 shows the VOT values for each of the three voiceless stops in English. In this figure, it appears that VOT values for /k/ are much longer than for both /p/ and /t/. On the other hand, /p/ and /t/ did not seem to differ in VOT values.

Figure 3-4: VOT for English Voiceless Stops with Standard Deviations

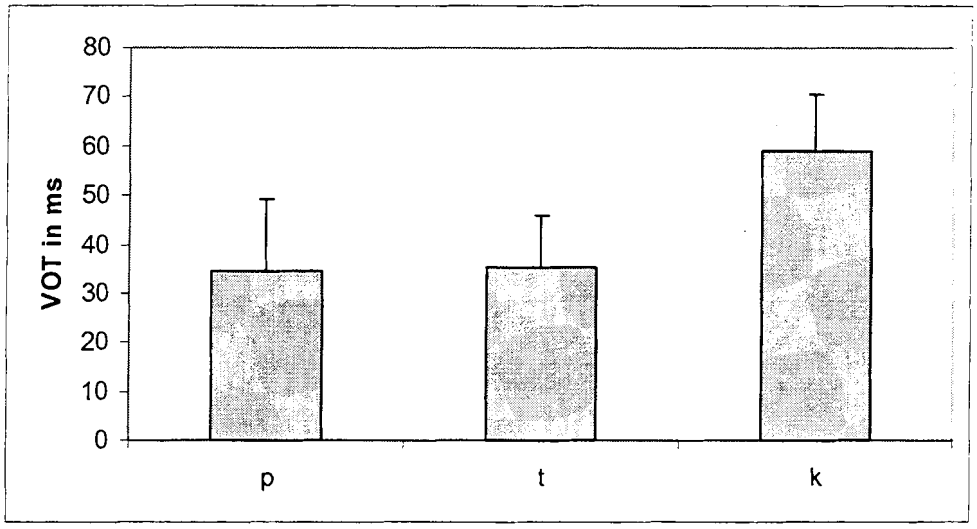
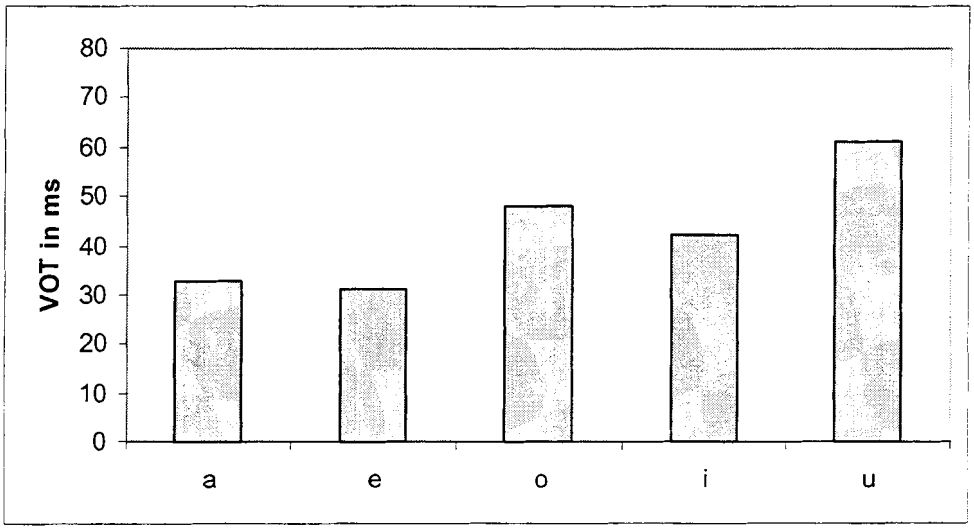


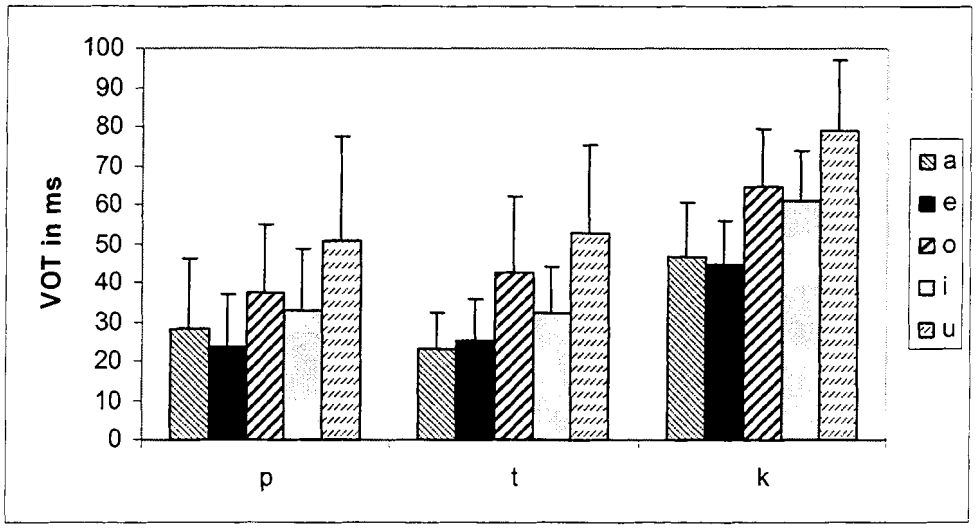
Figure 3-5 presents the overall VOT values for all the three voiceless stop consonants in front of each the five vowels. The VOT values of the stops before the high vowel /u/ appear to be longer than before any other vowel. The second longest VOT values appear to be when /o/, a mid vowel, follows. However, the VOT values before the other high vowel /i/ are long, but not as long as when /u/ or /o/ follows.

Figure 3-5: Mean VOT in front of the Five English Vowels



Another perspective on the results is given in figure 3-6, which presents the VOTs for each English voiceless stop in front of each of the five vowels. The figure shows that the vowel context of /u/ and then /o/ affects all three voiceless stops, resulting in longer VOT values. The VOTs before the high vowel /i/ are third-longest for all three stops.

Figure 3-6: VOT for each English Stop in front of the Five Vowels with Standard Deviations



An additional two-way repeated measures ANOVA was performed on the English VOT data. Once again, the factors examined were Consonant (3 levels: p, t, k), and Vowel (5 levels: the closest English vowels to the five Greek ones, a, e, i, o, u). The ANOVA showed significant effects of Consonant [$F(2,38)= 106.19, p<.0001$] and Vowel [$F(4,76)=36.68, p<.0001$], but showed no interaction [$F(8,152)=1.7, p=.104$]. Post-hoc Bonferroni-adjusted *t*-tests on the significant effect of Consonant showed that English /p/ and /t/ produced by the bilinguals did not differ significantly in terms of VOT ($p>.05$). However, VOTs for /k/ were significantly longer than for both /p/ and /t/. The post-hoc tests on the significant effect of Vowel showed that the VOT values of the voiceless stops

were significantly longer before the high vowels, /i/ and /u/, but also before the mid vowel /o/ than before the two other vowels. VOT values before the low vowel /a/ were significantly shorter than before any other vowel, except for /e/. VOT values before /e/ were significantly shorter than before any other vowel, apart from /a/. VOTs before /o/ and /i/ were significantly shorter than before /u/, but did not differ significantly from each other. Table 3-2 summarizes the results of these comparisons indicating overall that VOT values were longer before both the high vowels (/i/, /u/) and /o/.

Table 3-2: Results of VOT Comparisons according to English Vowels

VOT for vowel pairs	Significance (Bonferroni-adjusted)
a<o	.0001
a<i	.05
a<u	.0001
e<a	**NS**
e<o	.0001
e<i	.0001
e<u	.0001
o<u	.05
i<o	**NS**
i<u	.0001

3.1.3 Comparison between Greek and English Data

A third set of analyses was carried out to compare the speakers' performances across the two languages. Such a comparison raises problems, because there is not a one-to-one correspondence between the Greek and English vowels. To remind the reader, Greek has the common 5-vowel inventory, in contrast to Standard Canadian English which has a 10-vowel inventory. Therefore, instead of ANOVA, selected comparisons were made just for certain vowels that are similar in the two languages.

Bonferroni-adjusted *t*-tests were performed across the two languages to compare consonants when the following vowel was /i/; the vowel that differs the least across the two languages. The VOT values of the voiceless consonants in the combinations /pi/, /ti/, /ki/ across the two languages were compared. Only in the case of English /pi/ versus Greek /pi/ ($p<.017$) was there a significant difference indicating longer VOTs for English. All other comparisons, Greek /ti/ versus English /ti/ and Greek /ki/ versus English /ki/, yielded no significant difference. The bilinguals appear to have distinguished the VOTs before the vowel /i/ between the two languages only for the voiceless stop /p/. However, they did not distinguish between /t/ and /k/ in the same vowel environment (/i/).

Additional Bonferroni-adjusted *t*-tests were performed when the following vowel was /u/; another vowel which is similar across the two languages. All the voiceless stop+u combinations (/pu/, /tu/, /ku/) in English have significantly longer VOT values than the equivalent ones for Greek ($p<0.017$, Bonferroni adjustment). Therefore, the bilinguals distinguish VOT values for all three consonants in the two languages when /u/ followed.

3.2 Results from the Analysis of Double/Multiple Bursts

In the stop productions analyzed in this study, the researcher encountered a number of double/multiple burst. Even though this type of production is a known phenomenon reported elsewhere in the research literature (Herbst, 2005; Turk et al., under review), it has not been examined closely. A stop was identified as a double burst stop, when initiated with two or more bursts of similar energy, separated with 20ms or less of silence (see also section 2.4). The burst(s) following the first one are considered to be a result of the Bernoulli effect. Following Herbst (2005), a non-double burst stop was

deemed to have occurred when the first burst preceded the second one with more than 20ms of silence. In this case, the first burst is not really a burst, but an unrelated articulatory gesture that for some people precedes the stop articulation. Therefore, the researcher carried out a more detailed examination of the instances of double bursts in the data.

As shown in Table 3-3, overall the Greek/English bilingual speakers produced more multiple bursts in English than in Greek. Also, as expected based on what the previous literature has reported, more multiple bursts occur with velar stops and then with alveolar ones among the three stop categories. However, a number of multiple bursts were found to occur with the bilabial stop /p/. The percentages presented along with the raw numbers of bursts in Table 3-3 give a more generalized picture, since they show the number of multiple/double burst instances as a proportion of the data used, after the missing data were extracted.

Table 3-3: Distribution of Multiple Bursts

Voiceless Stops	Greek		English	
p	7	(0.02%)	1	(0.003%)
t	11	(3.8%)	18	(6.3%)
k	14	(4.7%)	36	(12%)
Total of bursts	32	(3.6%)	55	(6.3%)

3.3 Accentedness Experiment Results

There was generally good overall agreement among the four listeners (inter-rater reliability) as indicated by a high intraclass correlation coefficient Alpha=.972 (Cronbach's α).

Ratings from the four listeners were highly correlated with each other, as seen in Table 3-4:

Table 3-4: Correlations among Listeners

Listeners	Pearson Correlations r
L1-L2	0.92
L1-L3	0.89
L1-L4	0.89
L2-L3	0.92
L2-L4	0.89
L3-L4	0.88

L1=first listener, L2=second one and so forth

Pooling over the listeners ratings for each sentence, their ratings for the three sentences were highly correlated: Sent 1-Sent 2, r=0.81, Sent 1-Sent 3, r=0.84, Sent 2-Sent 3, r=0.88.

Each listener was fairly consistent with him/herself across sentences as shown by the moderate to strong positive correlations of each sentence with the other two for each listener presented in Table 3-5.

Table 3-5: Correlations of Sentences within each Listener

Speaker	Sentences	Pearson Correlations r
L1	Sent 1-Sent 2	0.89
	Sent 1-Sent 3	0.87
	Sent 2-Sent 3	0.92
L2	Sent 1-Sent 2	0.62
	Sent 1-Sent 3	0.69
	Sent 2-Sent 3	0.80
L3	Sent 1-Sent 2	0.78
	Sent 1-Sent 3	0.66
	Sent 2-Sent 3	0.77
L4	Sent 1-Sent 2	0.69
	Sent 1-Sent 3	0.73
	Sent 2-Sent 3	0.77

The accentedness data were reduced by averaging across the ratings of each listener and then pooling across the listeners to calculate the mean accentedness score for each speaker. The pooled data are provided in Table 3-6 along with data on Age, AOA, AOL, LOR and % of Greek Use. The ratings range from 1.6 to 8.2 on the 9-point scale. To examine whether any of the factors presented in Table 3-6 predict accent ratings, Pearson correlations were calculated between accent ratings (Acc), and AOA, AOL, Age, LOR and % of Use (GKUse). Moderate positive correlations of the degree of Greek foreign accent with Age (r=0.56), LOR (r=0.54) and AOL (r=0.67) were found.

Table 3-6: Accentedness' Judgment Scores

SJ#	Age	AOA	AOL	LOR	% of Use	Overall Mean
G1	65	27	20	38	40	7.3
G2	62	20	20	42	20	4.3
G3	71	25	17	46	90	6.7
G4	39	23	16	16	60	6.9
G5	39	21	4	18	40	1.6
G6	42	25	10	17	15	3.2
G7	57	24	12	33	50	5.8
G9	55	27	28	28	80	6.5
G10	68	18	18	50	60	7.2
G11	57	19	14	38	60	5.3
G12	62	23	23	39	40	7.0
G13	60	27	15	33	0.5	5.4
G14	55	22	14	33	50	5.6
G15	64	19	19	45	60	7.6
G16	65	27	27	38	95	8.2
G17	57	19	19	38	95	4.7
G18	52	17	14	35	30	5.8
G19	61	32	16	29	80	5.7
G20	54	15	13	39	70	7.3
G21	78	29	20	49	10	6.5
Overall Mean	58.2	23.0	17.0	35.2	52.3	5.9

Pearson correlations were also computed between accent ratings (Acc), and the mean of Greek VOT values for all the voiceless stops (GMean), the mean of English VOT values for all the voiceless stops (EMean) and the difference between the Greek VOT values and the English ones (VOTDiff). The question examined was whether EMean and/or VOTDiff predict accent ratings. A significant negative correlation between Acc and EMean would indicate that shorter English VOT values were associated with a stronger accent in English. A significant negative correlation between Acc and VOTDiff would suggest that speakers who produce a larger difference between Greek and English VOTs had a weaker Accent in English. However, both set of correlations were not significant; Acc-EMean, r=-0.96 and Acc-VOTDiff, r=-.349. Therefore, the relationship

between Acc and EMean, and Acc and VOTDiff described above cannot be established. An interesting strong positive correlation was between EMean and GMean, r=.754, which can be interpreted as "the longer the English VOT values of the participants, the longer their Greek VOT values" .

The complete set of correlations among the variables are given in Table 3-7. The following correlations were also significant; GMean-LOR, r=.472, showing that the longer a participant resided in Canada, the longer the Greek VOT values that were produced; EMean-AOL, r=504 interpreted as "the younger the participants started learning English, the longer their English VOTs; VOTDiff-AOL, r=-.588 that indicates that the younger a participant started learning English, the larger is the difference between his/her English and Greek VOT values. Another two significant correlations expressed some further characteristics of the sample of the bilinguals examined. Thus, the significant Age-LOR correlation, r=.899 demonstrated that the younger the participants were when they came, the longer they resided in Canada, while the correlation of Age-AOL, r=.566 showed that the older the participants were when they came to Canada, the later they started learning English.

Table 3-7: Intercorrelations among Speaker Variables

	Pearson Correlations r							
	Acc	GMean	EMean	VOTDiff	Age	AOA	AOL	LOR
GMean	.19	1	.754**	.072	.276	-.420	-.165	.472*
EMean	-.096	.754**	1	.709**	.012	-.404	-.504*	.196
VOTDiff	-.349	.072	.709**	1	-.278	-.163	-.588**	-.209
Age	.559*	.276	.012	-.278	1	.264	.566**	.899**
AOA	.072	-.420	.-404	-.163	.264	1	.296	-.185
AOL	.671**	.165	-.504*	-.588**	.566**	.296	1	.442
LOR	.537*	.472*	.196	-.209	.899**	-.185	.442	1
GKUSE	.370	-.354	-.397	-.223	.076	-.057	.333	.103

*= correlation is significant at 0.05 level, ** = correlation is significant at 0.01 level

Lastly, an independent sample test t-test was computed among high vs. low L1 use participants and the dependent variables: VOTDiff, Acc, GMean, and EMean. The question investigated was whether the amount of use of Greek influenced the Greek and/or English VOT values, the VOTDiff, or the accent of the bilinguals. The participants reporting 70% or more of Greek Use were categorized as High Use (six participants), whereas the ones reporting 30% or less were grouped as Low Use (five participants); the participants reporting intermediate Greek Use scores (60, 50, 40) were excluded from the test, nine participants in total. The two groups did not differ significantly on any of the variables. Thus, the use of Greek did not appear to influence the bilinguals examined in their VOT and sentences productions.

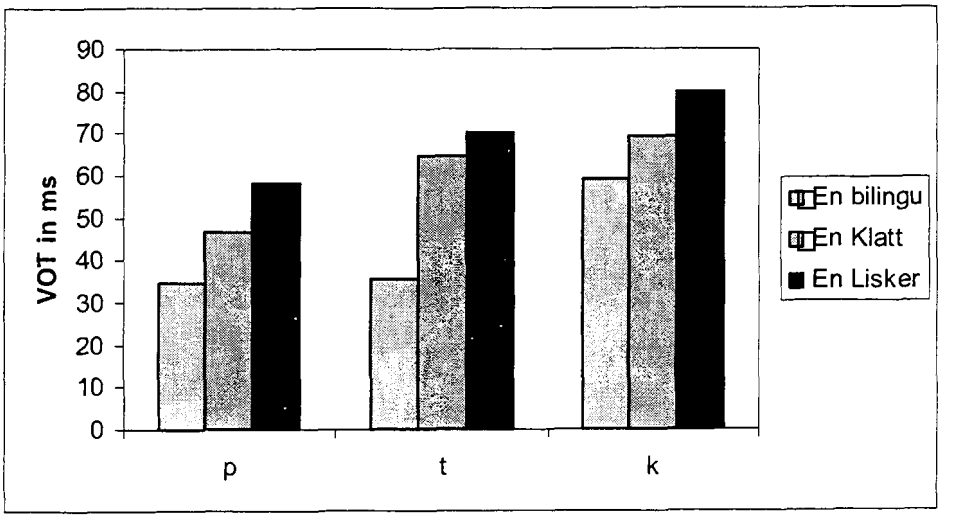
3.4 Comparison of Bilinguals' VOT Values with Studies on Monolinguals

As shown in many previous studies presented in section 1.2.4., late bilingual speakers usually produce intermediate VOT values for L2. That is, their L2 VOTs are between the VOT values of L1 monolinguals and L2 monolinguals. A few studies have shown that L1 VOTs, influenced by L2, can also be intermediate. The design of the

present study - control groups for Greek and English monolinguals were not included - did not allow the researcher to directly test the above (Hypothesis I and II, as presented in section 1.2.6). However, comparing the VOTs produced by Greek/English bilinguals with those of monolinguals of Greek and English discussed in other studies offers an indication of whether their English and/or Greek VOTs were intermediate. (Intermediate English VOTs mean shorter VOTs than those of English monolinguals and longer than VOTs of Greek monolinguals, whereas intermediate Greek VOT values mean longer than VOTs of Greek monolinguals and shorter than VOTs of English monolinguals.)

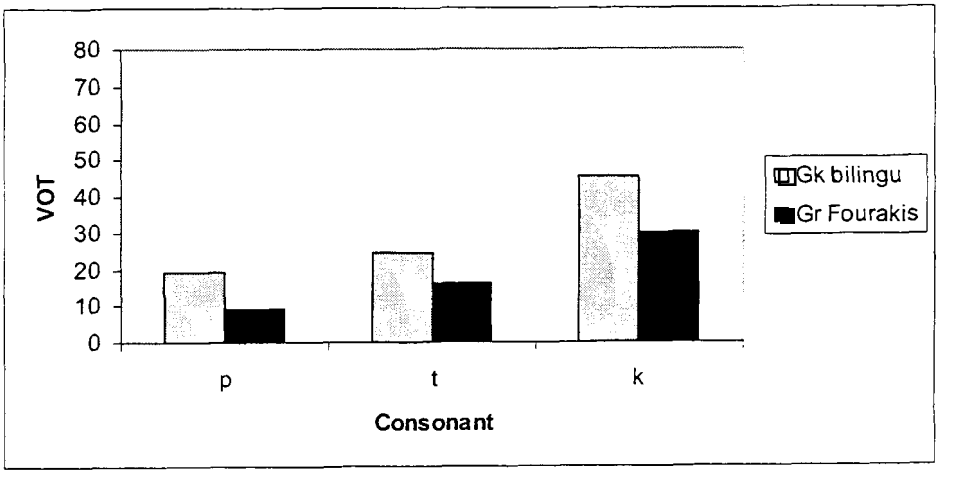
The English VOT values of the bilinguals were compared with those produced by the monolinguals tested by Klatt (1975) and Lisker and Abramson (1967), as seen in Figure 3-7. To give more information for these studies, Klatt (1975) studied VOT values of word-initial voiceless stops before the vowels /i/, /ɛ/, /ay/, /u/ and sonorant consonants, while Lisker and Abramson (1967) studied them in all positions in both words in isolation and running speech. The Greek/English bilinguals appear to produce English VOT values that are shorter than those of the monolingual English speakers in the two studies.

Figure 3-7: VOT of Bilinguals Producing English Stops Compared with Klatt's Findings



The VOT values of the Greek/English bilinguals are presented in Figure 3-8 along with Fourakis's results for Greek speakers (1986). Fourakis studied the VOT of word-initial voiceless stops before the five Greek vowels (/a/, /e/, /i/, /o/, /u/). Greek VOT values of bilinguals appear to be longer than VOTs of the monolingual Greek speakers examined by Fourakis.

Figure 3-8: VOT of Bilinguals Producing Greek Stops Compared with Fourakis' Findings



CHAPTER 4: Discussion

4.1 Cultural Context

The sample of participants used in this study was drawn from the Greek/Canadian community of Greater Vancouver in British Columbia, Canada. This population is estimated to be approximately 13,000 to 14,000 individuals, while in the whole Province of British Columbia there are about 18,000 to 20,000. Greek settlers came to B.C. in three different immigration waves: the first one was in the late 1800's, the second one was during and after World War II, the decades of 40's and 50's, and the third one was during the 60's and 70's, when many Greeks sought to escape the military dictatorship that governed Greece from 1967-1974. After the last wave, there have been only sporadic arrivals of Greek immigrants. The current Greek/Canadian Community in the Vancouver area mostly includes immigrants from the third immigration wave, a few from the second one and a small number of more recent arrivals.

The participant sample in this study reflected this distribution; fifteen of the participants belong to the third immigration wave, two, G10 and G21, to the second one, while the three youngest participants in the study, G4, G5 and G6, can be categorized as recent arrivals from Greece. Two points must be underlined here. First, this categorization coincides with some socio-linguistic characteristics of the participants. Those of the first and second wave had minimal or no knowledge of English before coming to Canada. Also, the fact that they came along with many other compatriots

meant that they socialized among themselves most of the time after arriving here. Second, the latest arrivals had more extensive exposure to English before coming to Canada. Greece during the last decades has been more prone to the influence of English-speaking culture (songs, English-speaking movies and other elements); thus more people nowadays study English in Greece. Also, after arrival in Canada, these participants knew few people of Greek origin who were of the same age. This reality probably drove them to spend most of their time with other Canadians who were either native speakers of English or non-Greeks; thus they used English for communicative purposes. Overall, these recent arrivals would have less everyday use of L1/Greek in comparison to the participants who came as a part of the past immigration waves. This is supported by the demographic data of this study, since the youngest participants, G4, G5, and G6, reported a lower weekly use of Greek compared overall to the use reported by the participants from the past immigration waves.

4.2 VOT Results

The main purpose of this study was to examine the effect of bilingualism on Greek and English VOT values. This goal was achieved by addressing research questions 1-4 presented in section 1.2.6. These questions ask 1) whether the participants distinguished the VOTs of the two languages, and 2) which speaker-related factors can predict their English, or 3) their Greek VOT values, or 4) their accentedness ratings. The study also explored the question of whether they have created new categories for English voiceless stops.

The analysis of the Greek VOT data showed more complex patterns than might have been expected on the basis of previous work. In particular, the interaction of Vowel

and Consonant factors was found to be statistically significant. This was mainly attributed to the fact that: a) VOTs of all the Greek voiceless stops were longer before the high vowels, /i/ and /u/, than for the non-high vowels, except for /p/ in which VOT was longer only before /u/, but not /i/, and b) VOT values for bilabial /p/ and alveolar /t/ differed significantly in all environments, except when the vowels /o/ and /u/ followed. These results contradict Fourakis's (1986) findings that show a homogeneous effect of the high vowels for all three stops, and clear differences in VOT values for /p/ and /t/ in all environments.

Concerning the English production data, the statistical analysis showed no significant interaction, although both the Vowel and Consonant factors influenced VOT significantly. The consonant factor was significant, but English /p/ and /t/ as produced by the Greek/English bilinguals, did not differ significantly in VOT values, contrary to the results of Klatt (1975) and Lisker and Abramson (1967) for monolingual English speakers. Both previous studies showed that English monolinguals produced significantly shorter VOT values for /p/ than for /t/. Also, as noted above, Fourakis (1986) showed that Greek monolinguals produced shorter VOTs for /p/ than for /t/ in Greek. It appears that the Greek/English bilinguals in this study had not acquired fully native-like patterns of L2 pronunciation, since they did not produce VOTs as long as those of native English speakers as reported in other studies. Another question arising here is that since the Greek/English bilinguals generally distinguished between /p/ and /t/ VOT values in their L1/Greek, why did they not do so in English? This outcome may provide evidence of an interlanguage system, where the bilinguals deviate from both L1 and L2 patterns and follow a new different pattern, as Wang and Behne (2007) showed for Mandarin/English

bilinguals. A possible reason behind this new pattern could be based on the following: VOT values for Greek /p/ are much shorter than for English /p/; in fact, they are typically less than half as long according to previous studies. This large difference may have been readily noticeable to the Greek speakers during their acquisition of the English sound system. As a result, the bilinguals seem to have put much effort into producing aspirated /p/, resulting in VOTs almost double those of the Greek /p/, though still shorter than English /p/. The difference in VOT between English /p/ and /t/, however, is relatively small in comparison, and may not even have been noticed by the speakers during their acquisition of English. If so, they may have succeeded in producing longer VOTs for both /p/ and /t/ in English than in Greek, at least in some vowel contexts, while still producing undifferentiated VOTs for English /p/ vs /t/.

With regard to the Vowel factor, it was significant in the bilinguals speakers' English productions, because VOT values for the three consonants varied according to the following pattern: /u/ > /i/, /o/ > /e/, /a/. This pattern is similar, but not identical to, the patterns produced by the same speakers in Greek. In particular, the three Greek stops each showed slightly different effects of vowel context (e.g., the VOT of /pu/ was longer than that of /pi/ but the VOT of /ti/ did not differ from that of /tu/), whereas there was no evidence of such variable effects in the English VOT data. For these speakers, then, producing English voiceless stop consonants entailed more than simply transferring Greek patterns of production into English. Instead, different contextual effects appear to have resulted from different production strategies in the two languages.

The comparison of VOT values across the two languages revealed still more complexity in the results. The VOTs were first compared when the vowel /i/ followed,

which is similar across the two languages. In that context, the bilinguals did not differentiate the voiceless stops across the two languages in terms of VOT. However, when VOT values were compared before the vowel /u/, the bilinguals produced significantly longer VOTs in English than in Greek. In that context, then, they did distinguish VOT in voiceless stop categories across the two languages. The above results support the idea that the differentiation of L1 and L2 consonant productions is context dependent. In these data, clear differentiation occurred only when /u/ followed the voiceless stops.

Although, the bilinguals sometimes produced VOT differences between stops in their two languages, they did not appear to completely separate stop categories for Greek and English. The answer to the first research question asking whether the bilinguals would distinguish VOT values between the two language systems is yes, but only partially. The bilinguals appeared to distinguish VOT values between the two languages before /u/, but not before /i/. These results can be connected to the question of whether the Greek/English bilinguals created new phonetic categories for the English voiceless stops or not. This question is addressed in the end of this section.

With reference to research questions 2 and 3 addressing the speaker variables that possibly predict Greek or English VOT values, none of the correlations between the VOT values and the factors computed was significant. Thus, none of the factors examined here-AOA, Education level in Greek, Education level in English, LOR, Proficiency in Greek, Proficiency in English, and L1 use-predicted either the Greek or the English VOT values. To be more specific, early arrival in Canada (lower AOA) did not lead to longer English VOTs, as was expected. Also, longer residence in Canada (longer LOR) did not

lead to longer English VOTs or longer Greek VOTs. Nor did a higher education level in English result in the bilinguals producing longer English VOTs or longer–less authentic-Greek VOTs. The same was true for education level in Greek. Finally, greater L1 use did not coincide with longer English VOTs or shorter Greek VOTs. In general, the statistical analyses carried out here showed that these factors had no influence on the VOT productions of these participants.

To sum up, the Greek/English bilinguals in this study behaved differently than Greek or English monolinguals, since they produced longer VOT values in Greek than would be expected for monolinguals and shorter VOT values for all English voiceless stops than have been reported in studies of native English speakers. However, they did not merely produce English stops with Greek VOT values, since they produced longer VOTs in English than in Greek in at least some cases. For this reason, the bilinguals appear to have learned something new about stop production during their acquisition of English. These findings agree with the results of similar research on bilinguals (Flege, 1987, 1991, Major, 1990, 1992) showing that the bilinguals produce intermediate values for L2 and do not directly substitute L2 sounds with similar L1 sounds. At the same time, they appear to support another previously-reported finding—that the interaction of L1 and L2 systems is bidirectional (Flege & Davidian, 1985).

These findings agree with some of the predictions of the SLM (Flege, 1987b, 1991b, 1992). The SLM predicts that bilinguals will produce intermediate VOT values for L2, in this case, between the values of monolinguals of Greek and English. This phenomenon is caused by the strong influence of L1. Specifically, it may be seen as a result of the application of equivalence classification to similar sounds in L1 and L2.

On the basis of the SLM, it might be proposed that the late bilinguals did not create new phonetic categories for English voiceless stops, but differentiated the stops in Greek and English by applying different-language specific phonetic realization rules (Flege, 1991a, 1991b, 1992). This might lead one to predict that the bilinguals would produce intermediate L2 VOT values distinct from L1 values in all environments. However, this was not true for the Greek/English bilinguals' data. More specifically, SLM Hypothesis 5 by Flege (1991b: 239) refers to the blocking effect of equivalence classification for the formation of a new category that can result in two diaphones produced under one category; eventually these two will resemble one another in production. The data seem to support this proposal in that English and Greek VOT values of the bilinguals are closer to each other than the values of the Greek and English monolinguals as reported in other studies. Overall, these data cannot lead to a definite answer to research question 1 of this study. Do these results mean that the bilinguals created categories only for some environments and not for others? Or, following Flege's point of view, did the bilinguals learn to apply language-specific phonetic rules only in some environments and not in others? These interesting unanswered questions require more research probing bilinguals' perception and production of stop consonants.

4.3 About Double/Multiple Burst Results

The phenomenon of double/multiple bursts, as mentioned in section 2.4, is known to occur with the velar stop /k/, and sometimes with the alveolar stop /t/. Multiple bursts have been explained as a result of the Bernoulli effect (Herbst, 2005; Turk et al., under review).

The multiple burst data for the Greek/English bilinguals in this study resemble those of speakers in previous studies, since velar /k/ appears to have the highest number of multiple bursts. However, multiple bursts were also found to occur with alveolar /t/; this phenomenon has been discussed but not demonstrated in previous studies (Herbst, 2005; Turk et al., under review). Interestingly, the existing literature does not refer to the possibility of multiple bursts with bilabial /p/, yet the results of this study showed many multiple bursts occurring with /p/, though they were less frequent than for the other two stops. It would be interesting if a future study were to show that multiple bursts are possible with bilabial /p/ and not an idiosyncrasy of these data.

Comparing Greek to English, the results showed that the number of multiple bursts was greater in English for all voiceless stops, except for /p/. More specifically, 14 multiple bursts were found for Greek /k/ versus 36 for English /k/, and there were 11 for Greek /t/ versus 18 for the English one; however, there were 7 multiple bursts for Greek /p/ versus 1 for English. The general tendency is a higher number (55 versus 32) of multiple bursts for English than Greek stops, as shown in Table 3-4 in section 3.3. This tendency was observed in each of the participants comparing his/her Greek to English data.

A possible explanation for this increase in the number of bursts is an attempt of the Greek/English bilinguals to produce appropriate aspiration for English stops by implementing multiple bursts. In other words, they may have tried to produce greater aspiration in English, but since they did not have the necessary control over the speech mechanisms, failed to do so and produced multiple bursts instead. However, the fact that the bilinguals also exhibited multiple bursts in Greek raises two questions: a) do Greek

voiceless stops inherently have multiple bursts, and b) are the multiple bursts on average as many as those produced by the bilinguals in this study? If the answer to this question is positive, then the previous possible explanation about increased aspiration by multiple burst is still valid. However, the results for /p/ remain unexplained by adopting this approach, because the bilinguals appear to produce more multiple bursts in Greek than in English. Some questions remain for future research concerning multiple bursts occurring with /p/, such as the following: a) Can multiple bursts happen with /p/ or was it an idiosyncrasy of the participants of this study? and b) Were the unexpected results for /p/ due to Greek /p/ inherently having multiple bursts or an English /p/ without multiple bursts?

The results of this portion of the study indicate some directions for future studies. The basic questions that can be explored are a) whether the increase in number of multiple bursts from Greek to English are the result of an attempt to lengthen VOT and b) whether the increase in the number of multiple bursts will be repeated in another sample of bilinguals.

4.4 Accentedness Data

The chief aim of this part of the study was to determine which factors would accurately predict the participants' degree of Greek foreign accent. Hypothesis 3 predicted a negative correlation of accentedness with increased English VOT values, while Hypothesis 4 predicted that greater AOAs would result in greater accent, thus a positive correlation.

With respect to the accent ratings, high inter-rater reliability was observed among the judges; in other words, they agreed among themselves. There were also high intra-judge correlations; that is, each judge was in high agreement with him/her self. These outcomes allowed the pooling of the data over the judges and over the repetitions of each judge.

Hypothesis 3 is not supported by the data, because the accentedness scores did not correlate with the English VOT values of the bilingual participants. The same was true for Hypothesis 4, as the accentedness scores did not correlate with AOA. However, there were moderate positive correlations of the accentedness ratings with the speakers' chronological age (0.56), LOR (0.54) and AOL (0.67).

The correlation with age can be interpreted as follows: the older the participants were, the stronger their Greek accent was. Since AOL correlated with the accentedness scores, this result indicated that the earlier a participant started learning English, the less accent he or she had. Concerning the correlation with LOR, the longer the participants stayed in Canada, the stronger their Greek accents were. This result is intriguing, since the opposite or no correlation at all would have been expected. However, this finding might be explained in accordance with the general remarks for the Greek/English bilinguals, as covered in section 4.1. The participants who lived more years in Canada belong to the second or third immigration waves; that is, they came along with many other people of their origin, age and status with whom they socialized. Therefore, it is likely that they mostly used Greek in their day-to-day affairs, while the use of English was restricted to the work environment and encounters in stores or public services. It must be also mentioned that when these immigrants arrived, most of them lived around

the traditionally Greek neighbourhood of Kitsilano. Its epicentre was West Broadway, where there are still plenty of Greek businesses and restaurants. All the needs of a Greek immigrant can be covered by businesses owned by Greeks. For example, they patronized a Greek doctor, hairdresser, grocer, etc. Therefore, there was no need for them to use English, except when going outside of the Greek neighbourhood or at work. However, when the newest arrivals came to Canada, the Greek-Canadian population was already dispersed all over the Greater Vancouver area. Therefore, these arrivals did not develop strong ties among themselves and the existing Greek community, but mingled with the general Canadian public.

Comparing these correlational results with the results of previous studies, some interesting observations can be made. Flege, Munro and McKay's results (1995) showed that AOL accounted for most of the variance in the accentedness ratings of the Italian/English bilinguals, a result that agrees with the significant correlation of accent with AOL that the present study showed. However, the positive correlation of accent with LOR contradicts the results of Flege, Yeni-Komshian et al. (1999) and Flege and Frieda et al. (1997) who both indicated that the AOA factor accounts for the accentedness ratings of the bilinguals. The cultural context presented in section 4.1 may explain this result for the Greek/English bilinguals. However, more research is needed to investigate whether these discrepant findings are due to the different L1 background or to some other factor.

Another interesting positive correlation reported in the results was between EMean (Mean of English VOT values) and GMean (Mean of Greek VOT values) (r= 0.754). This correlation shows that when the participants produced longer (and thus,

more authentic) English VOT values, they also produced longer Greek VOT values. In other words, they appear to have been more affected in their L1 when they were successful in producing L2 patterns.

Additionally, the non-significant results of the t-test comparing high and low L1-use participants showed that the two groups did not differ significantly in terms of VOT or accent. Thus, there was no evidence that the amount of L1 use affected the VOT values or the accentedness ratings. However, it must be mentioned that it is difficult to accurately estimate the exact percentage of Greek use. Also, there is no information how this percentage changed over the years that the participants resided in Canada.

To conclude, the answer to research question number 5 concerning which factors can predict the accentedness ratings, is the factors of age, AOL and LOR.

CHAPTER 5:Conclusion

5.1 Main Concluding Points

This study has yielded a number of conclusions which have theoretical implications concerning the acquisition of voiceless stops in a second language. The bilinguals investigated here were able to distinguish between voiceless stops of the two phonological systems with regard to their VOT values, but crucially not in all vowel environments. The results showed that the bilinguals produced different VOT values for the two languages when /u/ followed, but did not do so when /i/ followed. These results make it difficult to give a definite answer to research question 1, concerning the ability of the bilinguals to distinguish VOTs between the two languages.

The fact that the bilinguals overall produced significantly different VOTs for Greek and English supports Flege's (Flege, 1987a, 1991a, 1991b) notion of language learning mechanisms whereby phonetic learning ability remains intact throughout someone's life-span. However, the fact that the bilinguals did not produce different VOTs for Greek and English voiceless stops before /i/ suggests that the reality is not as simple as suggested by Flege's model. In other words, if the bilinguals created new categories, why did they not produce them before /i/? If they did not create categories, how did they succeed in clearly distinguishing VOTs in other environments? These results can be seen as supportive of the theory that interlanguage, the shared system of bilinguals, cannot be understood as the equivalent of two distinct language systems. As stated previously, the

two languages of bilinguals are not the same as those of monolinguals, but are in a constant state of flux.

Based on the results of the accentedness experiment, another important conclusion can be drawn. The fact that the scores did not correlate with English VOT values supports the conclusions of previous research (Flege et al., 1995; Munro & Derwing, 1995; Munro et al., 2006) that segmental errors may have less influence on global accent compared with other phenomena such as prosody or voice quality.

In addition, the results reported here offer support for Hypothesis 1 and Hypothesis 2. The Greek/English bilinguals appeared to produce intermediate VOT values for English: longer than for Greek stops, but not long enough to reach the target English values, as Hypothesis 1 predicted. In addition, the bilingual participants had longer VOT values for Greek voiceless stops, apparently due to L2 influence, than the Greek VOTs of monolingual Greek speakers, as Hypothesis 2 predicted.

5.2 Limitations of the Study

When designing this investigation, a series of variables were controlled, which resulted in some limitations. In particular, the study examined VOT of voiceless stops only in initial stressed syllables of disyllabic words. The words were of CVCV structure. Three of the Greek stimuli with a voiced stop consonant in the second syllable were produced by some participants as having a prenasalized voiced stop in the same position, e.g. /tuba/ vs /tumba/. Also, for the English stimuli, it was not always possible to find a real English word of CVCV structure complying with all the other requirements, so most of the stimuli have a CVCVC structure. In addition, the five Greek vowels do not have a

one-to-one correspondence with the vowels of the English phonological system. Therefore, the closest approximate English vowel was used instead for the first syllable of the English stimuli.

Some aspects of the present study that could be modified in future work are as follows: a) the participants could be selected so as to have a more continuous representation of AOA and percentage of Greek use, b) although, there was a good representation of all education levels, there could be more participants of lower education, c) more sentences and more English listeners could be included in the accentedness experiment. Finding more participants with lower education could show that education does not influence VOT production; therefore, a more representative sample would strengthen this result. With regard to the accentedness experiment, more listeners and more English sentences could support the accentedness results obtained.

5.3 Further Studies

This study could be expanded to voiceless stops occurring word-medially and word-finally in mono and polysyllabic words, while the stop closure of the stop consonants could be also studied. Also, the vowel environment could be further investigated by analyzing duration and the relevant formant frequencies.

The present study demonstrated some interesting patterns in the VOT and accented speech productions of Greek/English bilinguals, but it also showed the need for a study on Greek monolinguals and their VOT values in word-initial and word-medial environments, in stressed and unstressed syllables.

APPENDIX 1: Questionnaire

Questionnaire

1. What year were you born?_____

2. Where were you born?_____

3. Where did you grow up? _____

4. What is your job?_____

5. What is your highest education level or degree obtained?

a. Elementary	English/Greek
b. High school diploma	English/Greek
c. College degree	English/Greek
d. BA/BSc.	English/Greek
e. MA/PhD	English/Greek

6. What year did you immigrate to English-speaking Canada?_____

7. Have you left Canada and lived in another country for more than six months? If yes, please indicate the country and the time span spent there._____

8. How old were you when you immigrated to Canada?_____

9. At what age did you start learning English, if different from above?_____

10. Can you estimate your Proficiency in Greek, according to the following scale? (1 indicates low proficiency and 5 high proficiency)
    1 2 3 4 5

11. Can you estimate your Proficiency in English, according to the following scale? (1 indicates low proficiency and 5 high proficiency)
    1 2 3 4 5

12. Please estimate the time you spend speaking Greek, using percentages (%) in the following table?

	Family	Friends	Job
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			
Sunday			

13. Overall, in a typical week how much of your communication is done in Greek?(please use percentage)_____

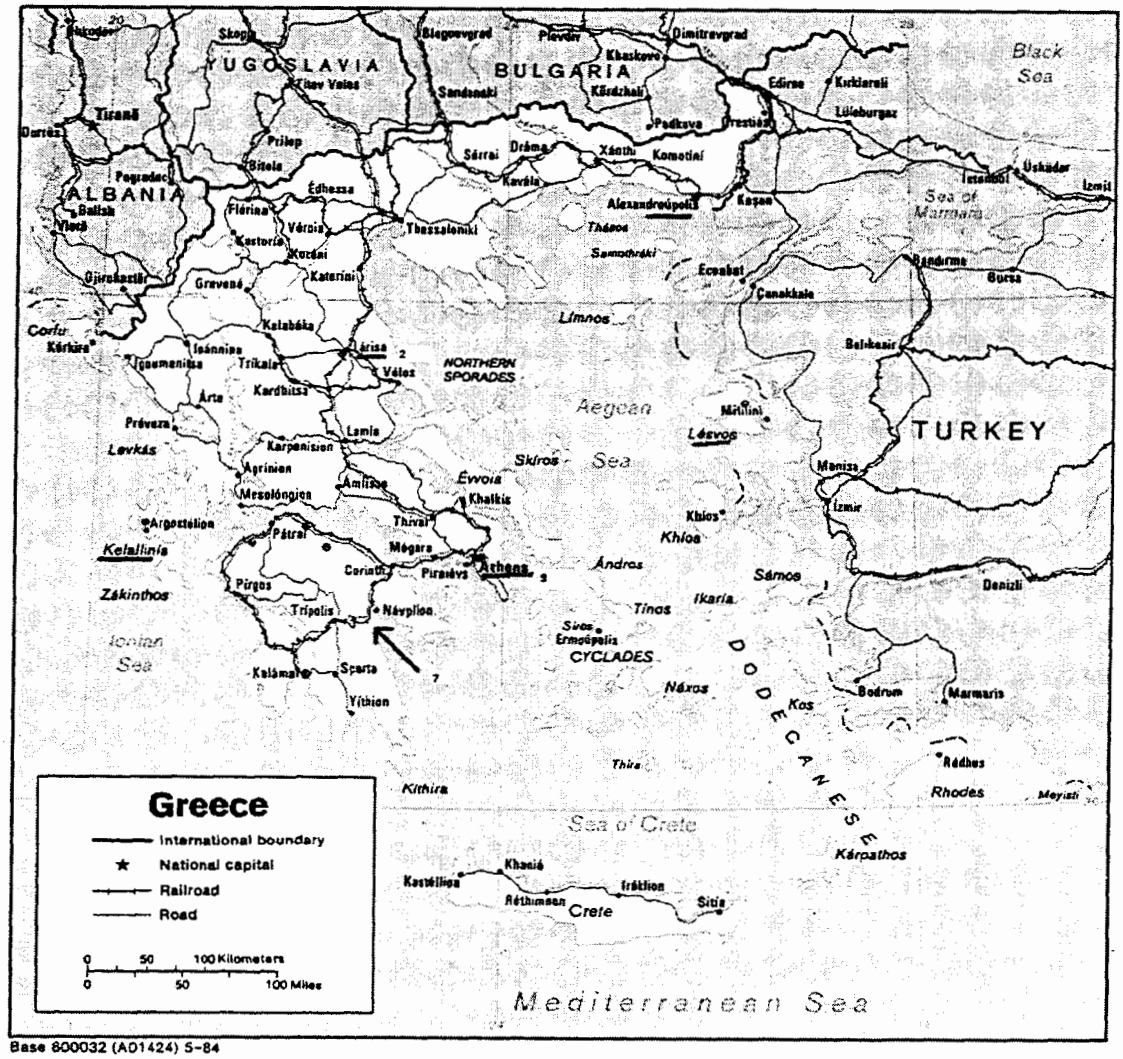
APPENDIX 2: Secondary Information Given in the Questionnaire

SJ#	Job	SEU family	SEU friends	SEU job
G0	Maritime Attaché	100%	100%	100%
G0f	MA student	100%	50%	10%
G0f2	High School Teacher	98%	70%	50%
G1	Retired stock broker, mining executive	72%	60%	5%
G2	Language Assessor	16%	2.5%	0%
G3	Fashion Designer	90%	90%	---
G4	Restaurant Owner	50%	60%	50%
G5	Online developer and marketing	40%	50%	10%
G6	Landscape Architect	0%	30%	0%
G7	Business Owner	70%	30%	0%
G8	Computer system analyst	100%	70%	0.1%
G9	Home economics/housewife	100%	80%	---
G10	Businessman	80%	60%	15%
G11	Manager, Bank customer service	50%	50%	0%
G12	Car Mechanic	50%	50%	0%
G13	Library Technician	0.8%	0.8%	0%
G14	Personal Banking Officer, retired	0%	50%	(80%)
G15	Travel Agent	80%	75%	60%
G16	Upholstery	100%	100%	40%
G17	Home economics/housewife	100%	100%	0%
G18	Special Education Assistant	100%	25%	0%
G19	Janitorial contractor	100%	75%	0%
G20	Medical Secretary	75%	70%	50%
G21	Retired Lawyer	0%	7.2%	8.6%

SEU: self-estimated use

In case that the participants reported different percentages for each day, the average percentage for each day is reported in the table.

APPENDIX 3: Map of Greece



Base 800032 (A01424) 5-84

This map was adapted from the website http://www.lib.utexas.edu/maps/greece.html. Courtesy of the University of Texas Libraries, The University of Texas at Austin.

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