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The development of voice onset time in French immersion children

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THE DEVELOPMENT OF VOICE ONSET TIME IN FRENCH IMMERSION CHILDREN

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Abstract

This thesis sought to examine the acquisition of French stop consonants assessed through the acoustic measure of voice onset time (VOT) in French immersion students from grades 1, 3, and 5. A speech production and speech perception task were administered in both English and French. Word-initial voiced and voiceless stops were investigated. Production analysis revealed that children maintained two separate language systems in the realization of all voiceless stops and the voiced stop /g/, whereas an interaction between their English and French sound systems was observed in the realization of the voiced stops /b/ and /d/. In the French perception task, children showed consistency in correctly identifying the voiceless tokens but demonstrated difficulty in the identification of the voiced tokens. The results are discussed in terms of the cross-language phonetic differences between English and French, the particularity of the learning environment, and the influence of an English dominant society.

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List of Abbreviations

ANOVA	Analysis of Variance
CAH	Contrastive Analysis Hypothesis
CPH	Critical Period Hypothesis
CV	Consonant Vowel
FI	French Immersion
HZ	Hertz
L1	First Language
L2	Second Language
M	Mean
MS	Milliseconds
N	Sample Size
SLA	Second Language Acquisition
SLM	Speech Learning Model
SD	Standard Deviation
VOT	Voice Onset Time

Chapter One: Introduction

1.1 Phonological Development in Second Language Learners

Phonological research in second language (L2) learning offers a broad perspective encompassing a wide array of factors pertinent to second language acquisition (SLA). For instance, phonological development in L2 learners is contingent on contextual factors, language specific articulatory and acoustic features, and individual differences—to name a few—all relevant when investigating the ultimate phonological attainment in L2 learners. The phonological development of child L2 learners has not only been documented on numerous accounts, but also in many different languages (see for example: Anderson, 2004; Harada, 2007; Lee & Iverson, 2011; Oh, Guion-Anderson, Aoyama, Flege, Akahane-Yamada, Yamada, 2011; Simon, 2010). Research in this area often aims to address whether bilinguals are capable of achieving native-like speech production patterns in their L2 in addition to whether they are successful in maintaining two distinct language systems between their first language (L1) and their L2. Studies investigating adult bilinguals have demonstrated that early childhood L2 learning generally leads to successful attainment of the L2 (Flege, 1991; Kang & Guion, 2006). By the same token, early exposure to the L2 usually allows for establishment of two distinct language structures between the L1 and the L2, while late exposure usually results in an interaction between the two (Baker & Trofimovich, 2005; Flege, Schirru, & MacKay, 2003; Guion, 2003).

To date, the majority of phonological L2 research has gravitated towards investigating the two language systems of a bilingual via a L2 majority society (e.g.

Simon, 2010; Tsukada, Birdsong, Bialystok, Mack, Sung, & Flege, 2005). These studies have often analyzed the case of immigrants who begin learning an L2 after moving to another country. Usually the L1 is upheld in the home environment while the L2 is the dominant language of the community. These individuals receive ubiquitous authentic exposure to the L2 and have plenty of opportunity to enhance their output. Such a context truly offers an organic L2 learning environment. Although a fairly comprehensive description of early L2 phonological development has been documented, the L2 acquisition process via a unique milieu—that of immersion schooling—has been neglected. The sociolinguistic context in which L2 learning occurs in an immersion program is rather different than the previous cited studies given that the L2 is not the dominant language in society and that immersion students are not surrounded by native speakers of the L2.

Immersion schooling is a form of bilingual education in which majority language students are immersed in a non-native language in a school setting. The instructional approach is to teach all course subjects and material in the L2 just as would be taught in an L1 mainstream English program, with the only substantial difference residing in the language of instruction. This educational stream is becoming an increasingly popular choice. Particularly in Canada, French immersion (FI) programs are widespread.

There are various reasons FI schooling continues to be a prominent stream of education. First, bilingualism has been shown to carry cognitive (Marian & Shook, 2012), emotional (Han & Huang, 2010) and employment (Chorney, 1998) advantages among others. The advantages aforementioned might incite parents to enroll their children in FI programs. Furthermore, considering Canada holds two official languages, it is advantageous for Canadian citizens to be able to communicate in both English and French. In the 2011 Statistics Canada Census, 5.8 million people nationwide (17.5%) reported being able to carry out a conversation in both official languages (Lepage & Corbeil, 2013). Certainly with such a large number of individuals acquiring an L2 with many being children, it is imperative for L2 research to continue thriving in order to further advance our knowledge in this domain, in effect providing valuable information useful to a variety of professionals (e.g. teachers, speech language pathologists). More specifically, given that English is the dominant language in most regions throughout Canada, L2 research with a focus on French acquisition via immersion schooling carries relevance while hitting close to home for a number of Canadians.

FI is a unique case of L2 learning as it leads to the moulding of a particular type of L2 learner. Unlike traditional bilinguals, FI students are generally only exposed to French in the school setting, thus they are predominantly surrounded by English speakers from the L1 dominant society. This type of L2 acquisition gives rise to coordinate bilingualism: the acquisition of two languages in different contexts (Caramazza, Yeni-Komshian, Zurif, & Carbone, 1973). L2 learning is thus contingent on the sociolinguistic conditions surrounding the L2 learner. In Alberta, Canada and most of Western Canada, English is the dominant language in society. FI programs are offered as a means to provide the opportunity for individuals to gain proficiency in the second official language of Canada: French.

In order to successfully devise L2 teaching tactics that will prove to be effective in the classroom such as in the immersion context, it is important for teachers to be familiar with SLA research. Accordingly, the more cognizant an L2 instructor is in terms of how the L2 learner comes to acquire a foreign language, the better adapted the L2 teaching approach will be. For instance, knowledge about expected developmental trajectory patterns will be useful in implementing teaching strategies and organizational schemes that will be most beneficial in promoting L2 learning to its utmost potential. As more phonological research is carried out, it can therefore be added to the existing body of knowledge of SLA to further improve the pedagogical approach in the immersion classroom.

Much of the *phonological* SLA research that has been shared with professionals in the L2 educational field has been derived from naturalistic L2 development outside of the classroom. It would be plausible to suggest that L2 findings extracted from a different sociolinguistic context would unfold rather differently and therefore will not necessarily be equally applicable to the classroom setting. However, empirical research that has been conducted in the FI classroom setting dedicating itself to French language skills, has focused on grammatical skills (Adiv, 1980; Day & Shapson, 1991; Harley, 1989, 1992), sociolinguistic competence (Lyster, 1994; Nadasdi, Mougeon, & Rehner, 2005), linguistic variation (Uritescu, Mougeon, Rhener, & Nadasdi, 2004) and discourse abilities (Swain, 1993; Swain & Lapkin, 2002).

Although research has been done in the FI classroom, to my knowledge research has yet to document the acquisition of L2 speech sounds via early FI schooling nor utilized specific acoustic measures in order to objectively assess speech acquisition in this population of L2 learners. Thus, the impetus behind this thesis lies in addressing this unexplored terrain of SLA in the immersion context. This distinctive L2 learning environment offers an ideal opportunity to examine the influence of the larger social context and the nature of L2 input in SLA, given that these two factors are characterized rather differently in an FI program when compared to the L2 learning situation in L2 majority societies. Moreover, students in an early FI program begin learning French at approximately five years of age, where age of L2 learning onset is held constant, thus enabling other factors pertinent to SLA to be examined. The findings of this thesis aim to provide insight into how this particular type of education will shape the ultimate attainment of French speech sounds in elementary school children.

1.2 Other Factors Influencing Native-like Proficiency

In addition to the social context and nature of input, various other factors have been shown to influence the ultimate realization of the L2 where SLA occurs through a rather intricate interaction of factors. The investigation of L2 development via FI provides an apposite window for highlighting the nature of the dynamics that are specific to this unique learning environment. The ease and proficiency of L2 acquisition can be attributed to a number of factors including: age of learning (Kang & Guion, 2006), the quality of the L2 input (MacKay, Flege, Piske, & Schirru, 2001), the opportunity for L2 output (Swain, 1985), length of exposure (Bohn & Flege, 1992), daily uses of L1 and L2 (Flege, Bohn, & Jang, 1997), the status of L1 and L2 in the society (majority vs. minority) (Mougeon & Beniak, 1991), the degree of acoustic similarity between the L1 and L2 (Baker & Trofimovich, 2005), and speakers' motivation and attitudes (Oxford & Shearin, 1994). Clearly, there are a number of elements that need to be taken into account when investigating the success of non-native language attainment. In this chapter, I will touch on various factors attributed to the aptitude of L2 acquisition in relation to their potential roles in FI schooling. Further, I will bring to light how these factors specific to the FI learning context might diverge from previous L2 acquisition research.

1.2.1 Age of learning

Age of learning is almost certainly the most widely documented factor in L2 acquisition research. Most researchers have come to the consensus that “the earlier the better” in regard to L2 learning. Early L2 learners are typically considered to be those who were first exposed to their non-native language in childhood. Previous studies have suggested that the earlier children are exposed to a L2, the more likely they are to achieve native-like pronunciation (Flege, 1991; Patkowski, 1990; Scovel, 1988). Long (1993) presents a literature review reporting on research findings that demonstrate support for L2 learners generally gaining phonological native-like proficiency if L2 learning commences prior to 6 years of age and with exposure to the L2 occurring on a consistent basis. This leads us to the ‘Critical Period Hypothesis’ (CPH) originally coined by Penfield and Roberts (1959), and later followed up by Lenneberg (1967). The premise of this hypothesis is that L2 learning that is initiated past a ‘critical period’ would be constrained by brain maturation inevitably leading to a compromised, non-native-like proficiency in the L2. However, controversy has surrounded what age constitutes the critical period. For example, Meisel (2010) has suggested as young as 3-4 years of age (specifically for L2 grammar related aspects); Krashen (1973) has suggested 5 years of age; Pinker (1994) 6 years of age; Lenneberg (1967) and Scovel (1988) 12 years of age; and more extremely, Johnson and Newport (1989), and Patkowski (1990) have suggested 15 years of age.

Rather than abiding by the CPH, a simpler notion resides in the cognizance that childhood bears a 'sensitive period' allowing early learners to generally acquire their L2 with more ease than late learners (Oyama, 1976). On the same grounds, early learners will be more apt to attain native-like competence than late learners (Flege, 1991; Flege, Mackay, & Meador, 1999; Kang & Guion, 2006; Patkowski, 1990; Scovel, 1988). Students who have been enrolled in an early FI program would be considered early learners by the *majority* of L2 researchers given that initial exposure typically begins at five years of age in kindergarten. Although French learning begins fairly early in life for FI children, the factors surrounding L2 learning in the FI program are quite different than previously reported studies, and will be further addressed later in this chapter.

As previously stated, a central focus of researchers in the L2 phonological field has revolved around exploring the two language systems of a bilingual speaker. Numerous studies have shown that *early* bilinguals may organize their two languages as somewhat separate systems (Baker & Trofimovich, 2005; Guion, 2003; Flege et al., 2003; MacLeod, Stoel-Gammon, & Wassink, 2009) whereas an interaction between the two language systems may occur with *late* bilinguals (Baker & Trofimovich, 2005; Flege et al., 2003). For example, Baker and Trofimovich (2005) conducted a study investigating the vowel acquisition of early and late Korean/English bilinguals and found that early bilinguals exhibited distinct realizations of L1 and L2 vowels. Interestingly, this was even the case in the early stages of the child's L2 acquisition. Further, vowel distinction improved with exposure to L2. On the other hand, the late bilinguals' L2 speech production patterns manifested as being 'colored' by their L1. In a recent study, MacLeod et al. (2009) examined the high vowel productions of early French-English bilinguals in

Quebec, and found that they are not only able to separate the two languages, but are also producing the vowels of each language in a native-like fashion. When interpreting such findings, the sociolinguistic context of the bilinguals should be considered. For instance, the results of Baker and Trofimovich's (2005) study apply to native Korean speakers residing in the U.S. where English is the dominant language. Further, they are immersed in a naturalistic setting.

Although the majority of previous studies have reported that early L2 learners exhibit comparable speech production patterns to monolinguals, some have suggested otherwise (e.g. Caramazza et al., 1973; Flege et al., 1997; Thompson, 1991). For instance, Caramazza et al. (1973) investigated stop consonants (/p/, /t/, /k/, /b/, /d/, /g/, also referred to as plosives) in early French-English bilingual speakers by means of the acoustic measure of voice onset time (VOT). VOT is an acoustic measure that refers to the time lapse between the release of a stop occlusion until the onset of vocal fold vibration (Lisker & Abramson, 1967). VOT analysis permits phonetic comparison across languages (a more detailed account is provided in section 1.4). Caramazza and colleagues found that when speaking English, the bilinguals' speech productions were imperfect and significantly different than monolingual English speakers, falling in the intermediary range between the French and English phonetic systems. More specifically, the VOT values of French-English bilinguals revealed interference from their first language (French) to their second (English). Flege and Eefting (1987) also reported on findings that adult bilinguals who had learned both Spanish and English as children (5-6 years old) produced non-authentic English stops. The authors posited that the non-native-like speech production patterns of the early Spanish-English bilinguals may be due to the

English accented speech input that they received as children. Flege and Eefting's (1987) results suggest that age of learning is not a sole determining component in relation to whether native-like speech production in the L2 will be achieved, given that in this case it appears that the nature of input received by the Spanish-English bilinguals may have overshadowed age of learning.

1.2.2 Nature of input

It has been postulated that the *nature* of L2 input plays a key role in regard to the ultimate attainment of an L2 (Harada, 2007; Khattab, 2000; MacKay et al., 2001). Flege, Schirru, and MacKay (2003) point out that the amount of foreign accented speech input an L2 learner is exposed to compared to authentic input, will influence the accuracy of L2 phoneme production. For example, support for the significant role that input can play in SLA comes from a study conducted by Harada (2007) who examined the speech production of word-initial stop consonants /p/, /t/, and /k/ in English-speaking children learning Japanese through an immersion program. Results showed that the students did not reach the Japanese target phonetic norm. Harada suggested that this may be due in part to the nature of the input received in the classroom. The teachers were bilingual speakers of both English and Japanese and were found to produce the Japanese plosives with significantly longer VOT values than monolingual Japanese speakers. This is one of the few studies to date that has examined the phonetic development of immersion children.

It is important to understand that in an immersion program such as FI, L2 input in the classroom is transmitted through both the instructor and fellow classmates.

Consequently, FI children are surrounded by other students who are at a similar level of French learning and who are also native speakers of English. This non-native input between peers is likely to play a role in the students' French pronunciation. If there is a lack of authentic target French models in the school setting, then students generally do not have access to non-accented speech unless their teacher is a native French speaker. Although FI teachers are bilingual, they may or may not be native speakers of French and children receive instruction from a single teacher throughout the course of the school year.

1.2.3 Opportunity for L2 output

Most individuals would agree that active practice is imperative to the ultimate success of any new type of endeavour whether it be taking up a new musical instrument, a new sport, or a new cooking hobby. Acquiring a new language would be similar in that practice is necessary in order to become highly proficient in the L2. In regard to speech production, new articulatory strategies need to be learned, some viewed as rather challenging (e.g. English /r/ and /l/ for native Japanese speakers) and yet early learners living in an L2 dominant environment have typically demonstrated success in acquiring the L2 (Flege, Munro, & MacKay, 1995; Flege, 1991). The ample exposure that L2 learners receive residing in a L2 dominant society affords vast opportunities for output. Conversely, in an FI program, French is generally confined to the classroom. Children are not exposed to French in the outside community such as a trip to the grocery store, during extracurricular activities, or through the media, as would occur in an L2 majority society. Consequently, the only L2 verbal practice that typically occurs is during class time such as reading aloud, answering questions posed by the teacher, presentations, etc. Having said that, it has been observed that there is a limited opportunity for output in the FI classroom (Swain, 1985; Cummins, 1998). Researchers have claimed that much of the interaction that occurs in the class setting is teacher-centred where course material and learning is transmitted in such a way that students are given less opportunity for creative and problem-solving activities in generating the French language (e.g. Harley, Allen, Cummins, & Swain, 1991). Unfortunately, limited opportunity for L2 output leads to less speech production practice for the L2 learner. Swain and Lapkin (1995) bring to light the importance of output, and attest that at times output may even assist input and further facilitate L2 learning.

1.2.4 Sociolinguistic context

The majority of L2 research has reported on individuals who are acquiring their L2 in an L2 dominant society generally finding support for the ability of early L2 learners to establish two distinct language systems (e.g. Flege, 1991; Flege et al., 2003). For instance, a study conducted by Flege (1991) showed that early Spanish-English bilinguals living in an English dominant society, first exposed to English at 5 or 6 years of age, were able to distinguish their L1 phonetic categories from those of their L2. Individuals who are immersed in an L2 majority context receive continuous input from native speakers, further facilitating attainment towards unaccented speech in addition to the formation of two separate language sound systems. Given that FI students are not surrounded by native French speakers nor is the L2 the dominant language in society, we would not necessarily expect for these early L2 learners to display similar SLA behavior as previously documented in early L2 learners who are residing in their L2 dominant society. When the L1 is the dominant language in society (e.g. English in Alberta) and the L2 learner is immersed in a minority language (e.g. French in Alberta), evidently, they have a different learning profile than what would exist when the L2 is the dominant language in society (e.g. a native French speaker living in Alberta learning English as an L2). Thus, FI research offers the opportunity to examine how the sociolinguistic aspect of SLA might be influencing the acquisition of the L2 in early learners who have typically been reported to attain native-like proficiency.

1.2.5 Degree of acoustic similarity between the L1 and L2

As has been reported, even early L2 learners do not always achieve native-like speech production patterns in the L2 (Caramazza et al., 1973; Flege & Eefting, 1987; Flege et al., 1997; Harada, 2007; Thompson, 1991). This finding may have to do in large part with the factors previously discussed such as nature of input, opportunity for output, and the sociolinguistic situation. Yet another notion has been put forth in regard to ultimate SLA and has to do with the intrinsic structure of a language. Two opposing theoretical frameworks have been proposed to account for an L2 learner's difficulty with L2 sound acquisition. Both models necessarily take into account prior language learning. According to both the Contrastive Analysis Hypothesis (CAH) originally proposed by Lado (1957) and the Speech Learning Model (SLM) developed by Flege (1995), the degree of cross-language similarity between the L1 and L2 plays a navigating role in whether L2 speech sounds will be successfully acquired. Lado (1957), considered to be a founder of 'contrastive linguistics', was one of the first to deliberate on the role of one's native-language in learning a foreign language. Lado claimed that the linguistic components that are similar across both the L1 and L2 will be more easily learned, whereas those that are different across the two languages will be more difficult.

Conversely, Flege's working SLM postulates that the greater the phonetic dissimilarity between an L2 phoneme and its closest L1 phoneme, the more likely the L2 sound will be accurately perceived and produced. Flege (2003) refers to this division of phonetic segments as "phonemic category dissimilation", inherently leading to a shift in phonetic space between the two languages. This thesis will address the CAH and SLM by highlighting the cross-language phonetic differences between English and French and will return to these two theories in section 4.2.2.

Along with the factors that have been highlighted in this section, other factors are equally likely to translate in the FI context. Such factors include: daily use of L1 vs L2 (Flege et al., 1997), speakers' motivation and attitudes (Oxford & Shearin, 1994), and length of exposure to the L2 (Bohn & Flege, 1992). In terms of the daily use of L1 vs L2, this factor coincides with the opportunity for output in an L2 learning context. Just like any practiced endeavor, the more the L2 is applied, the more advanced the L2 learner will become. Even though FI students are immersed in the French language for approximately 6-7 hours a day, their daily use of French is still limited (Swain, 1985; Cummins, 1998). Secondly, length of exposure to the L2 has revealed that the longer the exposure, the more proficient the L2 learner. For example, a study conducted by Lee and Iverson (2012), investigating word-initial plosive production of Korean-English bilingual children (five and ten-year-olds), found that length of exposure to the L2 played a prominent role in that ten-year-olds successfully distinguished all phonetic categories whereas, the stop systems had yet to be fully established for the five-year-olds. In the FI program, students are generally five-years of age when they are first enrolled and ten-years of age when they reach grade 5. If length of exposure is playing a significant role in the FI classroom, we would expect similar findings to those reported by Lee and Iverson (2012). Lastly, motivation has been shown to influence L2 proficiency. For instance, an L2 learner's attitude has been related to how often they implement L2 learning strategies (Scarcella & Oxford, 1992). It is not surprising that L2 learners who demonstrate eagerness to learn a non-native language will excel when compared to those who are less passionate in regard to L2 learning. Although these individual motivation and attitude differences were not directly measured in this thesis, such a factor is still relevant for the ultimate attainment of an L2.

1.3 Evaluating the Effectiveness of FI in Canada.

In the early 1970's, FI programs were formally introduced into Canadian schools (Allen, 2004). Given the positive response to this type of bilingual instruction, FI schools were shortly thereafter established across Canada and have become increasingly popular since 1970: a record 342 000 students attended these programs in elementary and secondary schools in 2011 (Friesen, 2013), and more specifically in Alberta alone, 36 753 students were enrolled in FI programs from 2011-12 (Alberta Culture, 2013).

The goal of FI is to cultivate L2 competency while at the same time, maintaining the first language. Lambert's (1975) theoretical framework proposes the concept of *additive bilingualism*—learning an L2 without jeopardizing the continual development of the first language (L1). FI education is a prime example of additive bilingualism; the student gains fluency in the L2 while the L1 is upheld, devoid of any L1 deterioration (e.g. Genesee, 1987). A predominant reason for this L1 preservation can be attributed to the societal context where FI students in Alberta reside in an English dominant environment with ample exposure to their L1 outside of the school setting.

Previous studies have evaluated the effectiveness of the FI program in respect to both English and French language skills. The importance of assessing FI students' English language skills is to ensure that FI student's L1 is not being compromised by this educational approach. Studies that have compared FI children to age-matched students enrolled in the traditional English program, have reported these students to lag behind English norms in literacy skills, but only up until grade 2 or 3 when English is formally introduced into the curriculum (Barik & Swain, 1975). After this point in early education, FI students have been shown to be comparable to monolingual English children in English language performance, while at times even out-performing their monolingual counterparts (Genesee, 1987; Lambert & Tucker, 1972).

Research that has devoted itself to investigating the effectiveness of FI programs in regard to French abilities has examined French language skills (e.g. vocabulary, comprehension) and French speaking skills (e.g. pronunciation). French language skills proficiency assessments have evaluated verb use (Harley & Swain, 1977), and syntactic structure (Adiv, 1980), among others. Such evaluations have examined French students' "rule" knowledge (e.g. accurate verb use), and have predominantly taken an objective approach. On the other hand, the examination of FI students' French pronunciation has been based on subjective evaluation by means of native French speaker ratings. The difference between the two assessments resides in that, by employing objective measures it is possible to obtain exact counts of syntactic errors, adjective use, verb use, etc. leading to a concrete analysis in terms of percentage of errors made or percentage of a language form used. On the other hand, the evaluation of French pronunciation skills of FI children in previous research has relied on native speaker ratings. These studies have claimed that FI students exhibit non-authentic French speaking abilities (e.g. Genesee, 1978). However, such assessment does not utilize acoustic measurements. The present thesis seeks to address this mark by utilizing phonetic instrumentation through the acoustic measure of VOT.

When FI students have been compared to Francophone age-matched children in French abilities, studies have reported that FI students are not analogous on all levels. For instance, Genesee (1978) reports on a longitudinal study conducted in Montreal from 1970-1976, where students enrolled in an FI program were comparable to Francophone children in certain aspects of comprehension, and in general demonstrated strong French proficiency. However, students did not attain native-like competency in pronunciation skills. Genesee asserts that the FI children exhibited a greater difficulty in generating language than decoding it. On the same premise, Harley et al., (1991) further point out the disparity between FI students and Francophone students in terms of expressive French skills. In general, studies indicate that immersion students display a greater difficulty in their expressive abilities than their receptive abilities, where they have shown to be comparable to Francophone children in certain aspects of comprehension, but to lag behind in written and verbal tasks (Genesee, 1978; 1987; Harley et al., 1991). Hammerly (1991) notes that even after 12 years of education in FI, students' pronunciation is English-accented. The French and English language skills noted above indicate that there is no threat in regard to attrition in the L1, and students generally become competent and adept in the L2, albeit short of native-like in terms of expressive abilities. Nonetheless, two problematic areas have been recognized in the enquiry of FI programs: verbal and written French language skills (e.g. Cummins, 1998).

1.4 Voice Onset Time

The current study set out to examine the verbal aspect of French language skills in FI children. Given that previous research in the FI classroom has claimed that FI students are falling short of native-like French speech patterns, it is appropriate to investigate whether such a finding would be observed through the objective measurement of an acoustic property such as VOT in FI students' speech production. Stop consonants were the focus of this study given that both English and French share the same stop consonants (/p/, /b/, /t/, /d/, /k/, /g/), but cross-language differences emerge in VOT plosive production between the two languages. As mentioned in section 1.2.1, VOT refers to the time lapse between the release of a stop occlusion until the onset of vocal fold vibration (Lisker & Abramson, 1967). It is the primary acoustic cue used to evaluate the production and perception of stop consonants in and across languages. VOT has been investigated on numerous accounts, but again mainly in a specific population of L2 learners: those who are acquiring an L2 in a region where the L2 is the dominant language (see for example, Baker & Trofimovich, 2005; Flege, 1991). This thesis attempts to take on a different angle by examining the VOT of children learning an L2 while residing in a L1 dominant society.

VOT is a useful acoustic parameter in bilingual research as it allows for a direct comparison between the sound systems of two languages. This comparison can be approached in two different ways: 1) A within speaker comparison can be carried out, where the L1 and the L2 of a bilingual speaker can be compared in order to examine the organization and directionality of a bilingual speaker's two languages. 2) An across speaker comparison can be made, where monolingual VOT values can be compared to bilingual VOT values in the L1 or L2. More specifically, in the case of FI students, these two approaches make it possible to address: First, whether L2 learners in an immersion program are differentiating the sounds of their native language (English) and non-native language (French) and second, whether their phonetic realizations are comparable to monolingual speakers of English and French. In addition, by evaluating VOT in FI students it becomes possible to examine the effectiveness of the FI program in shaping authentic VOT values of students enrolled in an early FI program.

VOT is often assessed by language researchers given that it carries phonetic information characterized by differences in lag time from the release of the articulators until the onset of voicing. Voicing is directly related to VOT as it is associated with the presence or absence of vocal cord vibration in the articulatory realization of a plosive. In English and French, stop consonants in word-initial position can be separated into two phonemic categories: voiced /b/, /d/, /g/ and voiceless /p/, /t/, /k/. Generally speaking, voiced stops are characterized by the vibration of vocal cords during the closure of an articulator whereas voiceless stops are characterized by the absence of vocal cord vibration during the closure phase. However, in English both voicing categories are often realized with silent closure intervals in word-initial position so another acoustic feature must also be considered in order to separate them accordingly: aspiration (Lisker & Abramson, 1964). Aspiration refers to the puff of air that is expelled following the release of a stop—a typical feature of English voiceless stops /p/, /t/, /k/—whereas, French voiceless stops are generally unaspirated (Coveney, 2001). The majority of languages can be divided into three distinct phonemic categories: 1) voiced stops, 2) voiceless unaspirated stops, 3) voiceless aspirated stops (Cho & Ladefoged, 1999).

1.4.1 VOT in Canadian English and Canadian French

Three modal VOT categories are used to distinguish English and French plosives:

1) Lead VOT: associated with the vocal cords vibrating before the stop release thus resulting in a negative VOT value—also referred to as prevoicing.
2) Short-lag VOT: associated with the voicing period beginning as soon as the stop is released thus resulting in small positive VOT values.
3) Long-lag VOT: associated with aspiration thus resulting in large positive VOT values.

An evaluation of VOT in the speech production of FI students will permit a cross-language comparison in order to determine whether FI students are producing authentic French VOT values that are consistent with the lead VOT and short-lag VOT categories typical of native French speakers (Table 1), and also whether FI children are maintaining distinct VOT realizations between their L1 and L2. A breakdown of authentic VOT ranges for both voiced and voiceless stops in English and French reported by Macleod and Stoel-Gammon (2008) is shown in Table 1 and a depiction of these VOT ranges is provided in Figure 1 and Figure 2.

Table 1. Typical range of VOT in the production of word-initial voiced and voiceless stops in English and French.[1]

	Voiced	Voiceless
English	Short-lag (0 to 20 ms)	Long-lag (65 to 150 ms)
French	Lead (-50 to -200 ms)	Short-lag (0 to 40 ms)

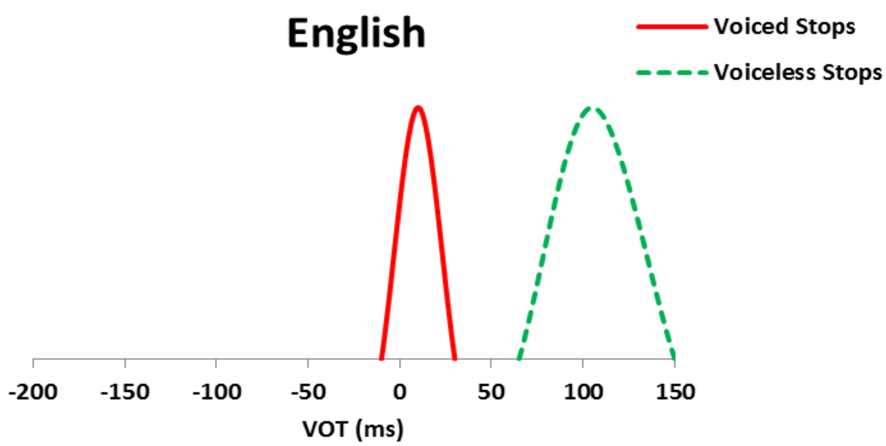

Figure 1. A visualization of the typical range of VOT in the production of word-initial voiced and voiceless stops in native English speakers.[1]

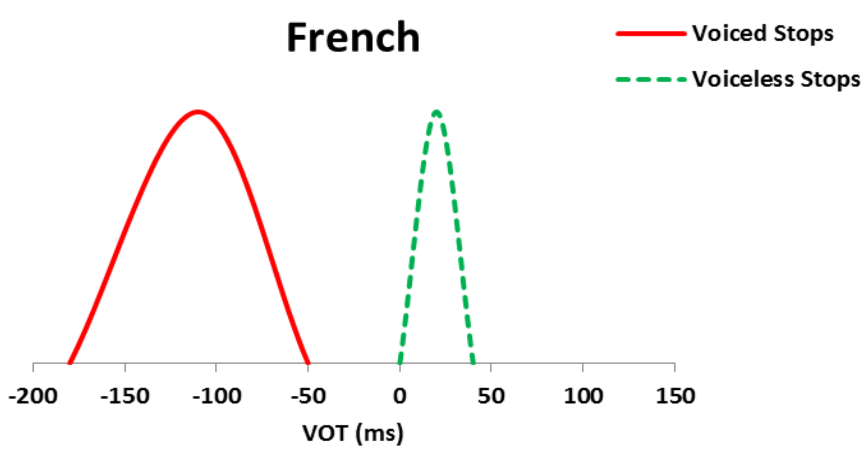

Figure 2. A visualization of the typical range of VOT in the production of word-initial voiced and voiceless stops in native French speakers.[1]

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[1] The VOT ranges from Table 1, Figure 1, and Figure 2 are taken from Macleod & Stoel-Gammon, 2008.

In English, the voiceless stops /p/, /t/, /k/ in word-initial position are realized with long-lag VOTs, typically around the 65 and 150 ms range (Macleod & Stoel-Gammon, 2008). Figure 3 provides a spectrogram of an eight-year-old FI student producing an English token with word-initial voiceless stop /p/. As the figure depicts, there is a substantial voicing lag (91 ms) from when the voiceless stop is released (the burst), until the vocal cords begin to vibrate. This long puff of air released, typical to English voiceless plosives /p/, /t/, /k/, leads to longer VOT values characterized by aspiration.

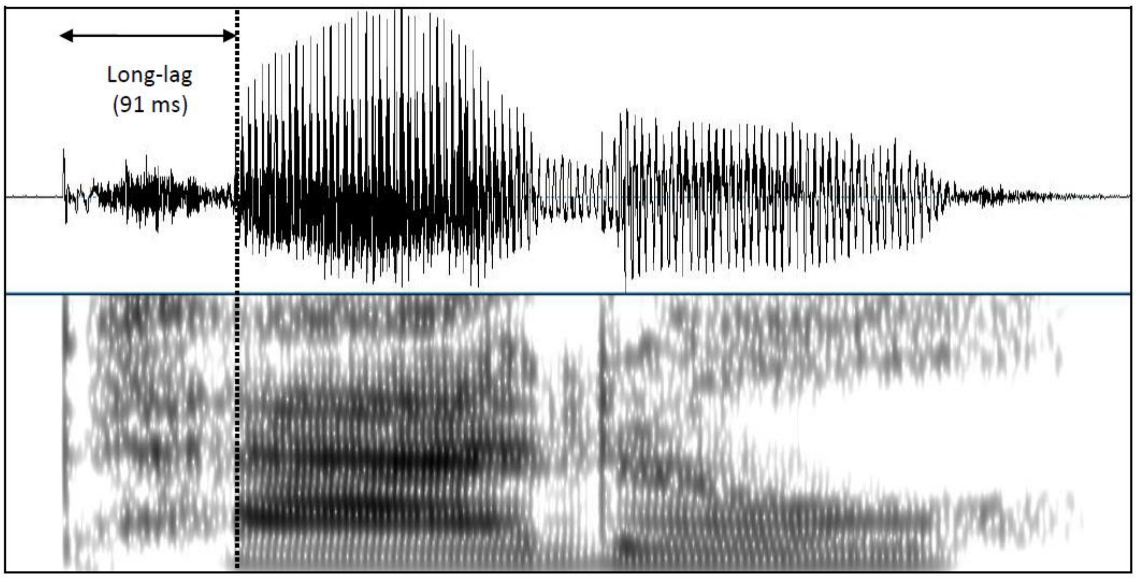

Figure 3. Waveform and spectrogram of English token "paddle" produced by an eight-year-old FI student. The dotted line represents where the aspiration ends and the vowel onset begins.[2]

Long-lag VOT (Figure 3) is a voicing category present in native English, characteristic of English voiceless stops but it is a voicing category that does not exist in native French where the latter's voiceless stops /p/, /t/, /k/ in word-initial position tend to

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[2] All spectrograms shown in this thesis are from the audio files of FI students' data collected through the current research.

have short-lag voicing, usually between 0 and 40 ms (Macleod & Stoel-Gammon, 2008). In other words, in the realization of /p/, /t/, /k/, voicing is delayed after the stop release in English, while in French the voicing begins as soon as the stop is released (Fagyal, Kibbee, & Jenkins, 2006). See Figure 4 for a spectrogram example of a short-lag French voiceless stop of 25 ms produced again by an eight-year-old FI student.

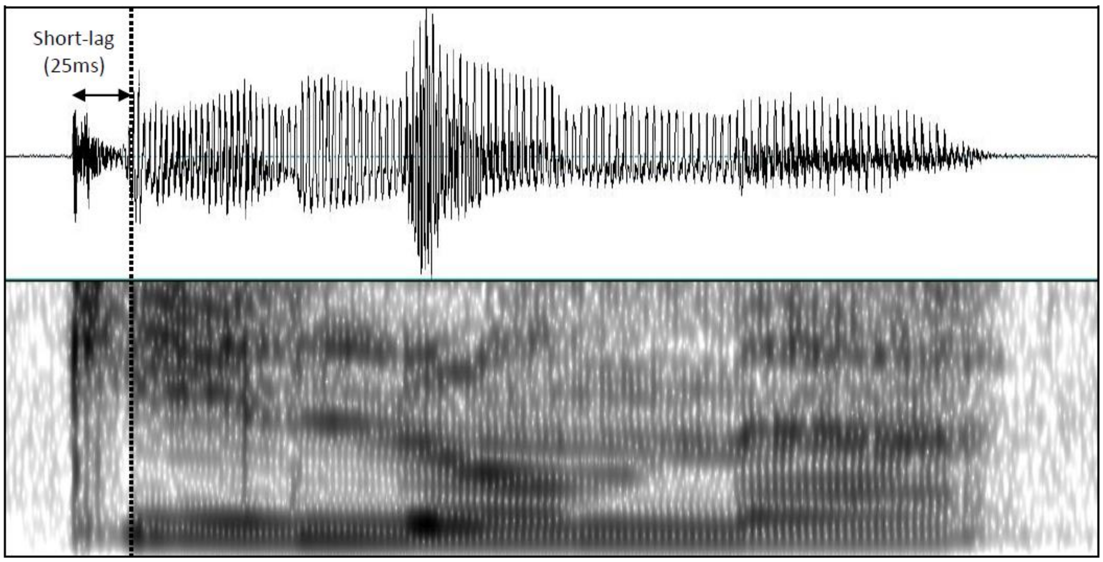

Figure 4. Waveform and spectrogram of French token "kilomètre" produced by an eight-year-old FI student. The dotted line represents the end of the short-lag VOT and where the vowel onset begins.

Next, when we compare the production of voiced stops /b/, /d/, /g/ in word-initial position between English and French, they are unaspirated in English and typically realized as short-lag VOTs usually around the 0-20 ms range (Macleod & Stoel-Gammon, 2008). See Figure 5 for a spectrogram example of a 6 ms short-lag English voiced stop. In French, voiced stops consist of heavy pre-voicing resulting in lead VOTs, typically in the range of -200 and -50 ms (Macleod & Stoel-Gammon, 2008). Figure 6 provides a spectrogram of a -86 ms prevoiced French stop. The spectrogram reveals that vocal cord vibration precedes the actual release of the plosive.

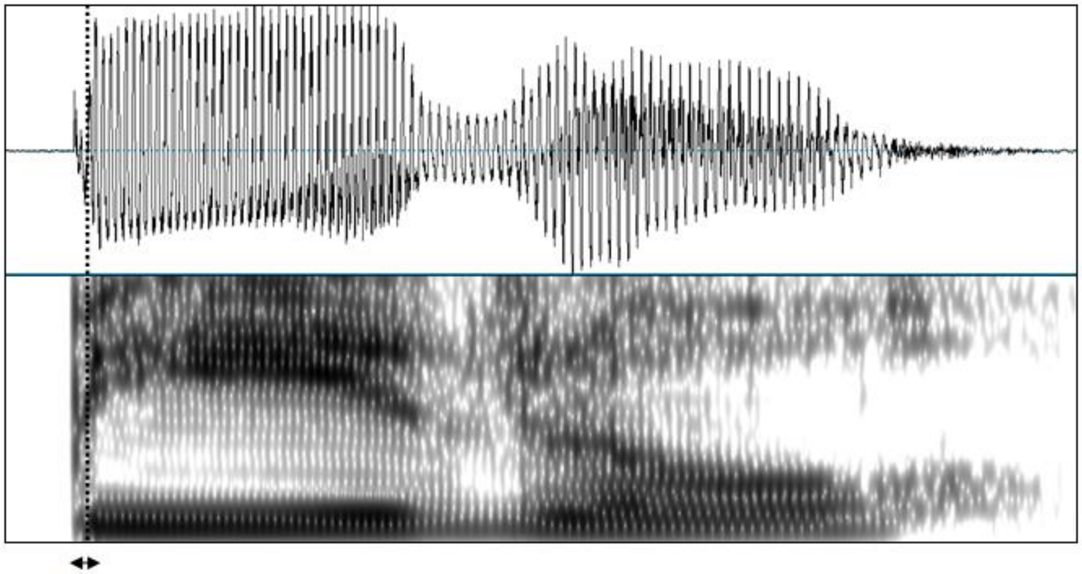

Figure 5. Waveform and spectrogram of English token "beetle" produced by an eight-year-old FI student. The dotted line represents the end of the short-lag VOT and where the vowel onset begins.

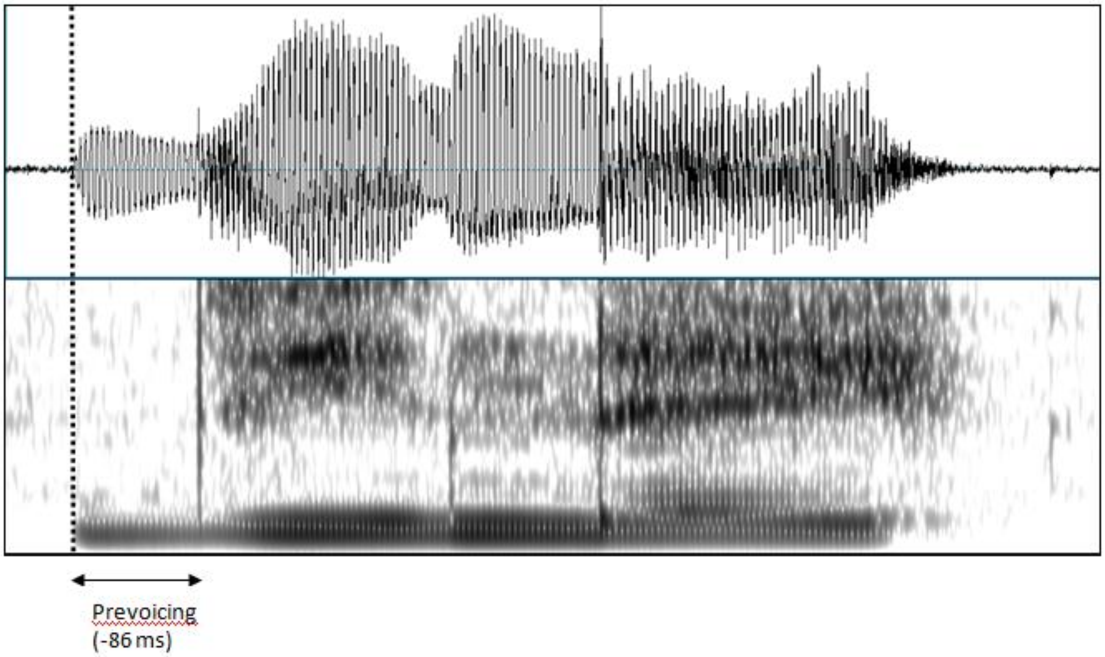

Figure 6. Waveform and spectrogram of French token “dîner” produced by an eight-year-old FI student. The dotted line represents where the lead voicing begins before the release of the articulators.

It is important to note that although English is said to be a language that contrasts short-lag and long-lag voicing categories, it is possible for the voiced stops /b/, /d/, /g/, (usually produced as short-lag), to be produced with vocal cord vibration preceding the release of the plosive (prevoicing). This phenomenon is reported as “free variation”. More generally, free variation is “seen as the behavioral manifestation of the lexical networks and systematic variation of the existence of a system” (Ellis, 1999). In the field of phonology, it is characterized by the variability of a phonetic component that may be observed in a particular language and does not alter the meaning of the linguistic token.

Researchers have reported prevoicing to be acquired the latest of all the voicing contrasts (e.g. Allen, 1985; Khattab, 2000). Rather complex articulatory conditions must be met in order to produce lead VOT. Firstly, the vocal folds must be adducted and tensed. Secondly, transglottal pressure needs to be adjusted accordingly (Van Alphen & Smits, 2004). It has been suggested that prevoicing may not be as salient of an acoustic cue as aspiration (Aslin, Pisoni, Hennessy, & Perey, 1981; Vanlocke & Simon, 2011). For instance, in an early study, Aslin et al. (1981) investigated VOT perception in 6-12 month old infants in an English environment and found that infants were more sensitive to VOT in the positive lag region than that in the negative lag region. If this is the case, then this voicing contrast may in fact pose more of a challenge for the FI students because of its lack of perceptual acuity.

Table 2 provides mean VOT values in the production of both voiced and voiceless stops of native Quebec French speaking children between the ages of 7-9 obtained from a study conducted by Ryalls and Larouche (1992). Table 3 also provides mean VOT values of native French speaking children but between the ages of 5-8 years of age from France (Scarbel, Vilain, Loevenbruck, & Schmerber, 2012). Lastly, Table 4 provides mean VOT values in the production of both voiced and voiceless stops of native English speaking children (Flege & Eefting, 1987). The French VOT values reported in Tables 2 and 3 will be used as a monolingual French comparison when examining the VOT realizations of FI students. Such a comparison will allow for us to examine whether FI students are approaching French target speech patterns or not.

Table 2. Average French VOT values (in milliseconds) produced by Quebec French speaking children between the ages of 7-9 years old. Taken from Ryalls and Larouche (1992).

	/p/	/t/	/k/	/b/	/d/	/g/
Mean	32	60	65	-91	-91	-88
SD	12	22	15	24	21	28

Table 3. Average French VOT values (in milliseconds) produced by France French speaking children between the ages of 5-8 years old. Taken from Scarbel, Vilain, Loevenbruck, and Schmerber (2012).

	/p/	/t/	/k/	/b/	/d/	/g/
Mean	39	45	61	-62	-49	-40
SD	31	26	30	56	50	53

Table 4. Average English VOT values (in milliseconds) produced by American English speaking children between the ages of 9-10 years old. Taken from Flege and Eefting (1987).[3]

	/p/	/t/	/k/	/b/	/d/	/g/
Mean	70	82	84	15	22	32
SD	15	16	14	7	9	8

[3] It is important to note that the values provided in Table 4 exclude all instances of prevoicing. Lead VOT was considered separately by Flege and Eefting (1987) and is not included in Table 4.

1.4.2. Stop consonant articulation

VOT varies between English and French in the production of stop consonants. However, this does not necessarily imply that the articulatory approach phase of plosive production is different between the two languages. Typically, French shares the same place of articulation with English for all plosives with the exception of a slight difference in /t-d/. English plosives /p/, /b/, /t/, /d/, /k/, /g/, are produced in three distinct regions of the vocal tract: /p-b/ are bilabial stops where the lips come together during the approach phase; /t-d/ are alveolar stops in where the tongue meets the alveolar ridge, and /k-g/ are velar stops where the back of the tongue presses against an area in between the hard and soft palate. However, a slight difference exists between the two languages for /t-d/ where, in French the equivalent of the English alveolar stops are apical dental stops (Dart, 1998). In other words, in the English production of /t-d/, the tongue meets the alveolar ridge whereas in French the tip of the tongue meets the front teeth. See Table 5 for a breakdown of manner of articulation in all six stops separated by voicing category. Cho and Ladefoged (1999) note that even though alveolar stops and dental stops do not share the exact same manner of articulation, their VOT realizations overlap and the air volume behind the closure is similar.

Although French and English share similar places of articulation in the production of plosives, VOT differs between the two languages in voiced and voiceless stops. It has long been recognized that VOT varies with place of articulation, beginning with Lisker and Abramson (1964). Although the researchers did not explicitly state the VOT distinctions in relation to place of articulation, their seminal study investigating 11 different languages revealed that velar stops elicit longer VOTs than both bilabial and alveolar stops with bilabial stops yielding the shortest VOTs.

Table 5. Place of articulation of voiced stops /b/, /d/, /g/ and voiceless stops /p/, /t/, /k/ in English and French.

	Bilabial	Alveolar/ Dental	Velar
Voiced	/b/	/d/	/g/
Voiceless	/p/	/t/	/k/

1.5 The Present Study

1.5.1 Purpose

The purpose of this thesis is to provide a description of the phonetic learning of FI students by exploring the VOT of all six word-initial stop consonants /p/, /b/, /t/, /d/, /k/, /g/ in both the speech production and perception of elementary school children immersed in an early FI program. This research aims to shed light on the effects of the nature of L2 input and a L2 minority environment in early L2 learning by examining the VOTs of students who were first exposed to the French language at approximately the same age. Furthermore, by examining grades 1, 3, and 5 it will be possible to evaluate the VOT developmental trajectory of FI children while at the same time, investigating the influence of length of L2 exposure. VOT allows us to investigate whether FI children are differentiating their two language systems and also whether the acquisition of word-initial stop production and perception are comparable to monolingual children. Through the examination of VOT, the L2 phonetic development of students immersed in a unique educational environment can be brought to light.

The present study confronts this uncharted territory by addressing the following questions:

1) What is the developmental pattern of the French voicing contrast in children of different grades and do children achieve a more native-like proficiency as the amount of exposure increases? By addressing this question it will be possible to examine the FI program's effectiveness in facilitating accurate L2 plosive production and perception. Of equal interest is whether FI students show a progression in the direction of the norm French VOT production patterns and perceptual identification functions with the succession of grades (1, 3, 5), and do the phonetic categories show a similar trend?

2) Are children able to maintain two separate language systems in the dimension of voiced and voiceless stops? This question serves to examine the dynamics of language interaction between the first phonetic language system and the second to determine whether there are observable cross-language phonetic influences. Is there a unitary system that develops for each acquired language or an interacting system? If two distinct systems are not observed, is there a transfer from L1 sounds to L2 sounds or vice versa? My research will examine whether the two language systems influence each other and if so, how this interaction changes over the course of the elementary school years.

3) Is there a link that exists between speech production and speech perception during this developmental process of French acquisition? This is a pressing question persisting in L2 learning research as it remains controversial. The comparison between the speech production and speech perception findings will aim to investigate whether

patterns observed in the L2 phonetic development of FI students are similar between the two aspects of SLA.

In order to address the research questions put forth, two separate experiments examining voiced and voiceless word-initial plosive production and perception were carried out: a word-repetition task and an identification task.

1.5.2 Implications

This research aims to provide an empirical and pedagogical contribution to researchers and professionals working with children acquiring an L2 in an immersion setting. Anderson (2004) remarks that clinicians often encounter child L2 learners. When an immersion student seeks help for a speech or language delay, it is important that a speech language pathologist is able to assess whether the problem lies specifically in L2 learning. Accordingly, the appropriate course of action can be taken in regard to therapy and/or continuation or withdrawal from the L2 program when L2 learners present with signs of language deficits.

By examining whether FI students are accurately producing and perceiving authentic French plosives, we can assess their success in L2 phonetic development specific to voiced and voiceless categories. The findings will prove useful in identifying which phonetic categories may or may not be posing difficulties in the L2 acquisition of students learning French in a school setting. By gaining a further understanding of how speech sounds are perceived and produced by the FI students, it then becomes possible to apply this new-found knowledge in making adjustments to current teaching strategies. Production training has been shown to be effective in improving L2 learners' pronunciation (Bradlow, Pisoni, Akahane-Yamada, & Tohkura, 1997; Mildner & Tomi, 2007; Vanlocke & Simon, 2011). Bearing this in mind, once we become cognisant of the phonetic segments that may be posing a challenge to FI students, we can acknowledge these short-comings by allocating extra attention to them.

1.5.3 Hypotheses

Given that age of learning has been attested as one of the most important factors contributing to the success of native-like proficiency in L2 learners, one might expect that FI students will attain the French target norm near the end of elementary school. According to the majority of bilingualism researchers (e.g. Flege, 1991; Guion, 2003; Krashen, 1973; Pinker, 1994), students enrolled in the early FI program beginning at the age of 5 would be considered early L2 learners (however, refer to Meisel (2010) for an argument against this). As mentioned previously, early bilinguals have generally been reported to reach native-like proficiency in their L2. Having said that, FI schooling offers a different type of L2 learning where students are immersed in a classroom with other English speaking children, thus they are not surrounded by native French speaking models. Generally the exposure to the L2 that the students receive is confined to the classroom setting with instruction from a single teacher for the entire schooling year. Moreover, the classroom teacher may or may not be a native speaker of French. Similar to the FI children, some teachers also took the FI route themselves when they were younger. Whether these students will ultimately reach the L2 phonetic prototype will be convoluted by multiple factors such as: age of learning, nature of input, opportunity for L2 output, and an L1 dominant society.

1.5.3.1 Experiment 1

During the initial stages of L2 exposure, the child has little experience with the new and unfamiliar language. When trying to produce new speech sounds it would be plausible to suggest that they will exploit their familiar native language for guidance. I predict that it will be the case that the FI students' L1 will play a role in how they produce French plosives, particularly in the early stages of L2 learning (grade 1). This in turn will lead to their L1 sounds transferring to their L2. In other words, I predict that L1 interference will manifest in the early stages of L2 learning where the French VOT values realized by grade 1s will be instances of their already intact L1 phonetic index. As a result, the L2 realizations of grade 1 FI students will not yield authentic French VOT values.

As immersion students advance in their L2 learning, I hypothesize that they will progressively begin to show a separation between their English and French sound systems with the potential of ultimately achieving a significant distinction between the two. More specifically, I speculate that in grade 3 students, we will observe intermediate VOT values between native French target norm and native English target norm in the FI students' French productions, whereas in grade 5, a significant distinction between the two language sound systems will be established. In addition, with the advancement of grades, I hypothesize that we will find a transition of VOTs progressing in the direction of the norm VOT of a native French speaker however still colored by the L1. Even though I predict that by grade 5 FI students will be likely to maintain two separate language systems, I suspect that they will, just as grade 1 and 3, fall short of the native French VOT norms. The reason for this is twofold; First, Harada (2007) found that the students enrolled in a Japanese immersion program never reached authentic Japanese production. Secondly, similar again to Harada's study, the confounding variables mentioned in section 1.2 (e.g. nature of input) are likely to play a prominent role in an immersion context. Although FI students are early L2 learners, their L2 learning environment is not typical of most previous studies that have reported native-like acquisition of the L2. See Figures 7-9 for a predicted visual VOT developmental trajectory illustration for the French voiceless stop /t/ of FI students in grades 1, 3, and 5.

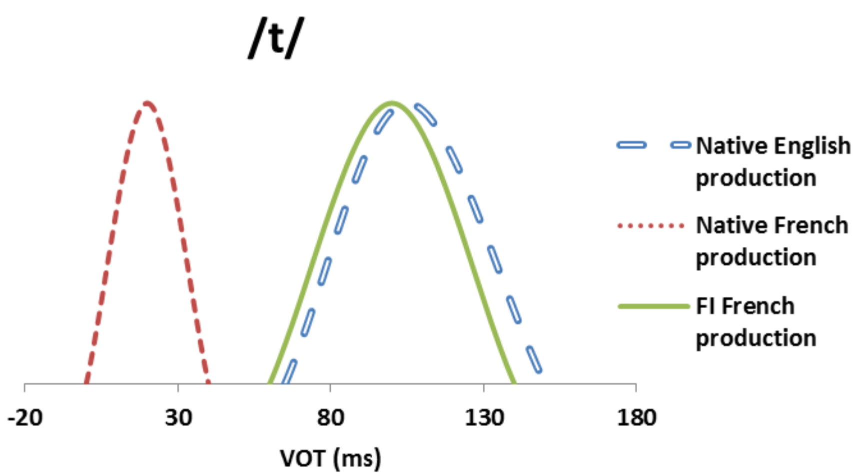

Figure 7. Predicted mean VOT values (in milliseconds) in the French production of word-initial /t/ produced by FI students from grade 1 in comparison to native English and native French speakers.

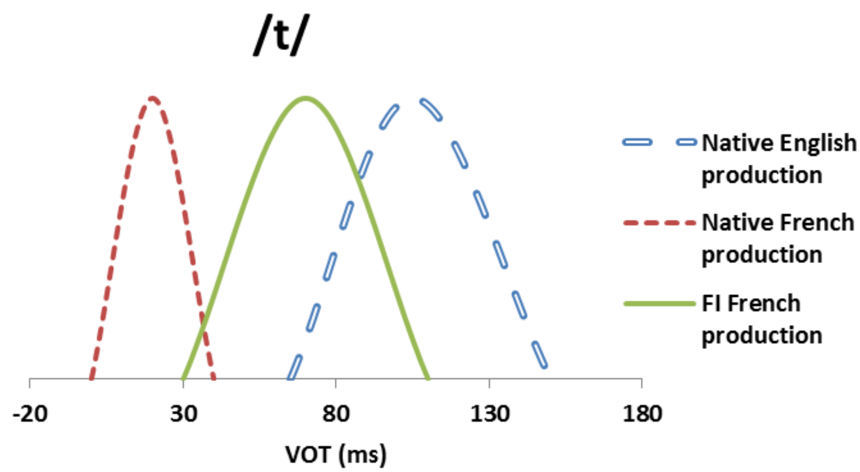

Figure 8. Predicted mean VOT values (in milliseconds) in the French production of word-initial /t/ produced by FI students from grade 3 in comparison to native English and native French speakers.

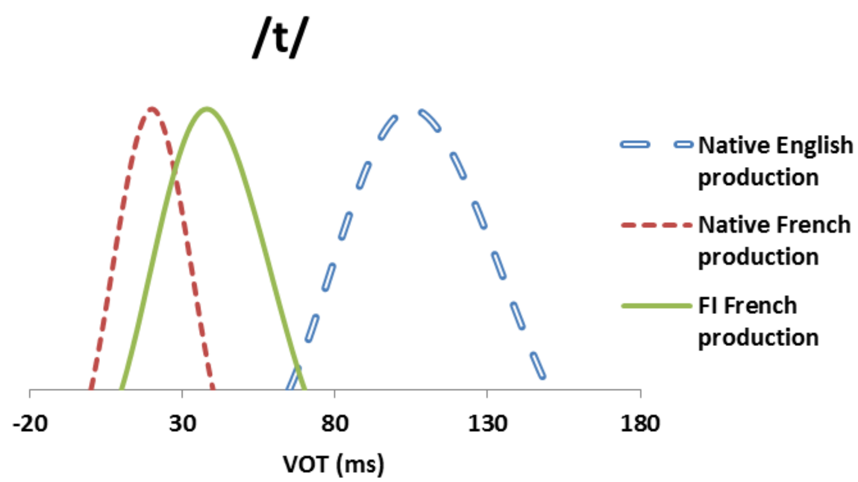

Figure 9. Predicted mean VOT values (in milliseconds) in the French production of word-initial /t/ produced by FI students from grade 5 in comparison to native English and native French speakers.

More specifically to voicing categories, I predict that students' French realizations of /b/, /d/, /g/ will at times manifest as instances of prevoicing due to the status of voiced stops in the English language. As mentioned previously, in English, voiced stops are in free variation meaning that there is a possibility of them being produced as either prevoiced or short-lag. Having said that, I suspect that when prevoicing does emerge in the production of French voiced stops, it will be minor and will not transpire as heavy prevoicing (characteristic of typical native French voiced stops). With all else being equal, for many FI students, heavy prevoicing is a novel category and prevoicing has commonly been shown to be the last phonetic contrast to be acquired while also proposed as the most difficult voicing category (Allen, 1985). Thus, it is likely that heavy prevoicing will be a challenge for French learners residing in an English dominant community. However, I suspect that as children advance through grade levels they will move closer to native-like prevoicing, albeit still not comparable to monolingual French speakers reported in the literature. Next, in relation to language transfer in the production of the voiceless stops /p/, /t/, /k/, I hypothesize that when speaking French, grade 1 students will produce these stops as long-lag (typical to the English language) rather than short-lag, thus realizing French voiceless stops as instances of English voiceless stops. Similar to the voiced stops, I hypothesize that in grade 3 a separation will begin to emerge with intermediate VOT values between native French target norm and native English target norm in the FI students' French productions, whereas in grade 5, a significant distinction between the two language sound systems will be established.

When we consider the two theories (CAH and SLM) discussed in section 1.2.5 in relation to the two language systems of FI children, voiceless stops between the L1

(English) and the L2 (French) more closely resemble each other than voiced stops as they occupy positive VOT space, albeit short-lag vs. long-lag. Whereas, voiced stops in French are characterized by *heavy* prevoicing and in English are generally produced as short-lag VOT with the possibility of also being *slightly* prevoiced. Heavy lead voicing typical of authentic French voiced stops is largely a new L2 sound category for native English speakers and is very different when compared to short-lag voiced stops typical of English. If the results from our study provide support for the CAH we would expect FI students to have less difficulty in successfully acquiring the French voiceless stops than the French voiced stops. This is because the distinction between English and French voiceless stops is closer in phonetic space than that of the voiced stops. Conversely, if our findings support the SLM, the opposite will hold true.

1.5.3.2 Experiment 2

In terms of the perceptual identification function, I predict that perception abilities will improve over the course of the school years in conjunction with an increase in French exposure. I hypothesize that the 1st graders perceptual VOT curve in French will be shallow given that they have limited French experience and are still in the initial stages of forming and perceiving separate sound categories in their L2. Having said that, I predict that their perception abilities will be more similar to grade 3 and 5 then production patterns given that during the first schooling year (kindergarten) and the first few months of grade 1, emphasis is placed on listening comprehension (as noted in Genesee, 1978). I predict that the 3rd grader's perceptual curve in French will be slightly steeper than the 1st grader's. As the years progress, we would expect the perceptual curve to sharpen, with 5th grader's displaying the sharpest curve, revealing a strong differentiation between the French phonetic categories. Moreover, in terms of the identification of voiced and voiceless stops, I suspect that children will demonstrate consistency in their identification of French voiceless stops given that both short-lag and long-lag VOT exist in English and so they will be familiar with this voicing. Whereas, because heavy lead VOT is generally a new category for FI students while it has also demonstrated to be a feature that falls short of saliency, L2 learners in the immersion program may exhibit difficulty in the perceptual categorization of French voiced stops.

Lastly, I hypothesize that for grade 1 students, it will be the case that their speech perception abilities will develop before their production abilities as they still have very limited practice in speech production when compared to the amount of exposure they have received in listening (beginning in kindergarten). Accordingly, I suspect that Grade 1 students will be more likely to correctly perceive a sound category while inaccurately producing the sound whereas after grade 1, perception boundaries will coincide with a child's speech production where a relationship between the child's perception abilities and production abilities will be observed. Below, I provide an overview regarding the proposed link between speech production and perception before proceeding to Chapter 2.

1.5.3.3 A link between speech production and perception

Researchers (e.g. Borden, Gerber, & Milsark, 1983; Goto, 1971; Polivanov, 1931) have long questioned whether speech perception precedes speech production or vice-versa (as cited in Cardoso, 2011). Nevertheless, many researchers would attest for the existence of an interplay between speech production and perception (e.g. Best & Tyler, 2006; Flege, 1993; 1995; Newman, 2003). Specifically, two influential models have addressed this link: The assimilation model proposed by Best & Tyler (2006) and Flege's (1995) SLM hold that the production of L2 sounds may be inaccurate if they are not correctly perceived by the L2 learner. Flege has found support for this relationship in a number of studies (Flege, 1993; Flege et al., 1997; Flege at al., 1999; Schmidt & Flege, 1995). Accordingly, it has been suggested that articulatory deficiencies might be concomitant with perceptual abilities (e.g. Monnin & Huntington, 1974). From a pedagogical standpoint, speech perception training in a foreign language has been shown to improve both perception and production (Bradlow et al., 1997; Rochet, 1995). Such findings provide support for Flege's SLM hypothesis for the existence of a direct link between speech production and perception. Research in the area of speech training that has shown improvements after instruction and practice suggest that these phonetic components can be modified and improved in L2 learners. Accordingly, implications for such findings are useful for professionals working with L2 learners suggesting that phonetic training can lead to target sound awareness thus having the potential to facilitate more accurate perceptual abilities and more authentic realizations.

On the contrary, other studies have found these two processes to be autonomous (Waldman, Singh, & Hayden, 1978; Zampini, 1998). For example, Zampini (1998) investigated the Spanish (L2) production and perception of stops /p/ and /b/ among adult native English speakers and found no correlation between their VOT production and perceptual abilities. On the same note, Hattori and Iverson (2009) found that improvement in speech production of an L2 does not absolutely lead to improved perceptual abilities. The authors examined the production and perception of native adults Japanese speakers in English /l/ and /r/ and found that production training led to an improvement in production abilities but their perception did not follow the same pattern. Findings continue to conflict to this day, in effect leading to the generally accepted notion that production and perception processes are intricate. It will be interesting to examine whether the present study will find support for such a relationship and if not, will accurate French speech production or perception be the first to emerge?

Chapter Two:

Experiment 1-Speech Production

2.1 Rationale

Plenty of research has been devoted to examining the effectiveness of FI schooling with a focus on academic performance, cognitive abilities, and language skills (e.g. Cummins, 1998; Johnson & Swain, 1997). Having said that, as far as I am aware, the L2 phonetic development in students attending an FI program has yet to be explored. Thus, a major gap in the literature exists in relation to what we currently know about the status of FI students' French language skills and between what has previously been documented in L2 phonological development outside of the school setting. It's important to address this missing link considering FI schooling has become a popular choice among Canadians. The FI program provides a unique case of L2 learning as students come to learn the L2 in a school context. Unlike the plethora of bilingual research that has documented the acquisition of an L2 in the natural home environment or an L2 dominant society, L2 learning via an immersion program affords a rather distinct learning approach. The divergence from typical L2 learning lies in that: 1) the child L2 learner is not surrounded by native French speakers, 2) the FI student receives L2 input predominantly from one language model who is not necessarily a native French speaker, 3) much of the time spent in the classroom involves listening to the L2 with much less emphasis placed on speaking, 4) generally the only exposure to the French language occurs in the classroom setting for approximately 6-7 hours a day. It is through the investigation of the trajectory of L2 phonetic acquisition via FI schooling, that the factors contributing to the proficiency of L2 learning particular to the FI learning environment will be underscored.

Owing to previous research, the little information that we do know in regard to FI students' French speech production is that their pronunciation has been attested to fall short of age-matched monolingual French children (Genesee, 1978; Hammerly, 1991). Previous assessment of FI students' oral skills has utilized qualitative measures when investigating pronunciation in the L2 (e.g. Genesee, 1978). A qualitative technique that is often employed is the rating of native speakers to judge the elicitations of an L2 speaker to be language appropriate or not. This type of evaluation provides researchers with an indication of whether FI students are exhibiting accented speech but does not instrumentally capture acoustic information in regard to language specific speech properties. Because of this lack of applied phonetic instrumentation in examining FI student's speech production we are not able to objectively discern where the students' French verbal abilities are missing the mark. For instance, languages differ in suprasegmental features such as pitch and stress relative to prosody, along with articulatory features such as vocal fold configuration and tongue height relative to stop consonant and vowel production, to name a few. By examining acoustic parameters such as VOT, it then becomes possible to obtain language specific quantitative measures thus shedding light on the phonetic realizations exhibited by an L2 learner.

The rationale for extracting acoustic values in the speech of an L2 learner is two-fold: Firstly, it allows us to explore the organization of an L2 learner's two language systems. More specifically, a comparison between the L1 and L2 enables researchers to examine whether the two sound systems are inherently different through the application of a within speaker statistical analysis of the acoustics. Such analysis will provide an indication of whether the L2 learner has successfully established two separate phonetic systems or whether interference is occurring between the two languages. Secondly, acoustic measurements facilitate a comparison between an L2 learner and monolingual speaker's acoustic properties. Both the L1 and the L2 can be compared to monolingual speakers to determine whether the L2 learner's L1 is being influenced by the L2 or vice versa. In addition, comparisons between monolinguals and bilinguals enable speech researchers to explore whether an L2 speaker is behaving similarly to a monolingual speaker in order to identify if the L2 learner has attained native-like speech production in their L2 and also to see if a bilingual speaker exhibits different speech production patterns than would a monolingual. Moreover, the L1 can be compared to monolingual speakers of the same language in order to determine if the L2 learner's L1 has shifted at all due to the influence of acquiring another language. The most encompassing research would involve both within and between speaker comparisons.

2.2 The Present Experiment

In this experiment, children participated in a word-repetition task eliciting the voiced stops /b/, /d/, /g/ and their voiceless counterparts /p/, /t/, /k/. Very little research has investigated both voiced and voiceless stops in early L2 French learners. The speech production task aimed to explore the developmental VOT acquisition process of both voiced and voiceless stop consonants in FI students by examining grades 1, 3 and 5. Of equal interest was the question of whether FI children establish a separation between their English and French sound systems. Monolingual English children served as a comparison group to further examine whether FI children's L1 is being coloured by their L2. Baker and Trofimovich (2005) note that there has been plenty of research comparing bilinguals' L2 to monolingual speakers but less so in comparing bilinguals L1 to monolingual speakers. Given that the present study collected data from monolingual English speakers, it becomes possible to explore how FI students' L1 may be influenced by L2 learning. Unfortunately it was not possible to collect data from monolingual French students here in Alberta, Canada. This is because the majority of individuals residing in Southern Alberta speak English as this is the dominant language in the community.

2.3 Methods

2.3.1 Participants

2.3.1.1 FI participants

Fifty-six English speaking children (38 female, 18 male) learning French through a FI program participated in the study. Our original sample size was of N = 60, but three children were removed due to having colds at the time of testing, recognized as possibly altering voice quality. One other participant was removed due to a poor audio recording. Students consisted of grades one, three, and five (18 grade one, 18 grade three, 20 grade five), ranging between 6-11 years of age (see Table 6 for participant breakdown). Students were tested at an early FI elementary school (École Agnes Davidson) in Lethbridge, Alberta, Canada. Students were recruited from seven different classrooms: 3 grade one classes, 2 grade three classes, and 2 grade five classes. A detailed description of the study was sent home to parents, and if they displayed interest in their child taking part in the study, they were asked to return the consent form back to their teacher. All participants were native speakers of English, with English being the language spoken in the home environment and in the L1 dominant community outside of the school setting. Students learned French through the immersion program and spoke no other languages besides English and French. For the majority of the immersion students (n = 53), French language learning began prior to the age of 6, with the exception of three students who were not introduced to French until 6 years of age. All participants reported as normal hearing with no known language, speech, learning, behavioral, or developmental delays and had never participated in any speech or language therapy programs. Parents filled out a detailed questionnaire prior to their child's participation and provided written informed consent. The questionnaire can be found in Appendix A.

Table 6. FI children's mean age in years and standard deviation separated by grade and sex.

	Grade 1	Grade 3	Grade 5
Males	$N = 5$ $M = 6.81$ $SD = 5.38$	$N = 5$ $M = 8.56$ $SD = 4.81$	$N = 8$ $M = 10.52$ $SD = 1.71$
Females	$N = 13$ $M = 6.66$ $SD = 4.25$	$N = 13$ $M = 8.75$ $SD = 3.51$	$N = 12$ $M = 10.56$ $SD = 4.68$
Total	$N = 18$ $M = 6.71$ $SD = 4.50$	$N = 18$ $M = 8.71$ $SD = 3.91$	$N = 20$ $M = 10.54$ $SD = 3.72$

2.3.1.2 Monolingual participants

Forty-five monolingual English children (25 female, 20 male), 15 six year olds (8 female), 20 eight year olds (12 female), 10 nine year olds (4 female) served as a monolingual English control group. See Table 7 for participants' mean age and standard deviation breakdown. Participants were recruited through advertisements placed in numerous locations throughout the city. They participated at the University of Lethbridge and were reimbursed with a toy and a $10 gift card for their time. All participants spoke no other languages besides English. All participants reported as normal hearing with no known language, speech, learning, behavioral, or developmental delays and had never participated in any speech or language therapy programs. Parents filled out a detailed questionnaire prior to their child's participation and provided written informed consent. The questionnaire can be found in appendix B.

Table 7. Monolingual English children's mean age in years and standard deviation separated by grade and sex.

	Grade 1	Grade 3	Grade 5
Males	$N = 7$ $M = 6.64$ $SD = 2.18$	$N = 8$ $M = 8.58$ $SD = 4.03$	$N = 6$ $M = 9.33$ $SD = 4.19$
Females	$N = 8$ $M = 6.49$ $SD = 4.44$	$N = 12$ $M = 8.57$ $SD = 2.89$	$N = 4$ $M = 9.73$ $SD = 4.59$
Total	$N = 15$ $M = 6.56$ $SD = 3.57$	$N = 20$ $M = 8.57$ $SD = 3.29$	$N = 10$ $M = 9.49$ $SD = 4.78$

2.3.2 Stimuli

The stimuli consisted of labial, alveolar and velar voiced and voiceless stops in word-initial position. A total of 54 tokens were produced, eliciting word-initial stop consonant target sounds /p/, /b/, /t/, /d/, /k/, /g/ (9 tokens per stop) with three consistent vowel environments /i/, /u/, /æ/ (English) or /i/, /u/, /a/ (French) immediately following the initial stop consonant. Each vowel was presented eighteen times, three times per stop. The stimuli consisted of monosyllabic, disyllabic, trisyllabic and quadrisyllabic tokens. See Appendix C for the list of stimuli for both the English and French experiments. Three randomized word lists were generated for each language. Audio prompts consisted of natural pre-recorded speech from a native female English speaker for the English component and a native female French speaker for the French component.

2.3.3 Procedure

VOT production of word-initial voiced /b/, /d/, /g/ and voiceless /p/ /t/ /k/ stops was assessed by means of a word-repetition task. The rationale behind opting for a word-repetition task was the fact that the youngest age group (grade 1) of FI students had only been exposed to French the previous year (kindergarten) for half-day school-days and so L2 learning was still in an early stage. It would prove difficult to sample an equal number of voicing category targets eliciting all of the target plosives and obtain an adequate amount of tokens if a picture-naming task was used. This is because grade 1 students' vocabularies are still limited and their ability to identify a picture eliciting the appropriate target-word would be restricted. Incertitude might arise that a word-repetition task could facilitate imitation, however support for this approach comes from a study carried out by Olmstead, Viswanathan, Aivar, & Manuel (2013) who investigated native English and native Spanish speakers imitation abilities of /ba/-/pa/ ranging on a VOT continuum from -60 ms to +60 ms. The researchers demonstrated that accurate VOT imitation manifested only in the voicing range present in one's native language, whereas speakers did not succeed in imitating tokens that fell outside of the native language VOT range. It is indeed plausible, that similar to the intentional imitation task results obtained from Olmstead et al. (2013), FI students who are engaging in a word-repetition task, likewise will not display accurate imitation behavior in regard to the L2. In effect, the natural VOT speech production abilities of FI students are likely to be captured.

Participants were tested individually over the course of two sessions (an English session and a French session) performed on different days. During testing, participants were sat at a desk in front of a computer in a quiet room. Verbal instructions were given in English prior to the commencement of the experiment in which participants were told that they would see an image appear on the computer screen while at the same time hearing a word played over the speakers (Logitech Z205, model: S-00094 used for the FI group; Edirol MA-7A used for the monolingual English group) and were asked to repeat the word back into the microphone after the audio prompt had finished playing. The audio recording was played at a comfortable listening level. A Shure SM87A microphone was used, with a sampling rate of 48000 hertz and was a placed at distance of approximately 10-15cm from the participant's mouth. Children's speech production was recorded using a Marantz flashcard recorder (model: PMD661). A practice trial (5 tokens for English, 10 tokens for French) was performed prior to the experimental condition so that children became comfortable with the task before beginning. Monolingual English children participated in the English production experiment, whereas FI children participated in both the English and the French production experiments, performed on separate days. The computer program *show & play* (Edwards & Beckman, 2008) was used to couple the auditory stimulus with the visual stimulus. The paradigm is depicted in Appendix D. Two French-English bilingual researchers administered the test and monitored the children's' speech elicitations. If the test administrators deemed the participant's pronunciation to be an overt incorrectly produced token, the researcher would play the speech token again and the child was asked to listen closely and then repeat it back into the microphone. Mispronunciations and repetitions were not included in the final analysis. A total of 1.9% of FI students' French elicitations were removed, 0.9% of FI students' English elicitations, and 0.4% of monolingual English childrens' elicitations.

2.3.4 VOT measurements

The speech stream was segmented using Praat software (Version 5.3.39) (Boersma & Weenink, 2013). After segmentation was completed, it was possible to label time points (i.e. burst, voice onset) for each speech token. The plosive burst release and voice onset were marked in order to extract VOT for acoustic analysis. The burst was identified as the peak of an individual spike from a cluster of spikes that make up the transient of constriction release and was recognizable by the first clear deviation from the zero crossing in the waveform. Voice onset was identified by locating the beginning of the first voicing cycle. This point was identified by an upward swing rising above the zero crossing just before periodicity of the waveform. After all labelling was completed, VOT was extracted from each token, for each child.

Six university students who were familiar with Praat software were trained in the temporal labelling procedure and assisted with this task. In order to assess the reliability of temporal marking across the six individual labellers, an Intraclass Correlation Coefficient test was conducted on 9% of the audio files. All six students labelled the same ten files. There was an extremely high level of agreement yielding a coefficient of .983.

2.4 Results

This experiment set out to examine both the developmental pattern of the French voicing contrast in children of different grades, as well as the organization of the two language systems of voiced and voiceless stops in FI students. By means of grade comparison it was possible to determine whether FI student’s VOT realizations change over the course of the schooling years and whether improvement toward a more native-like proficiency would be observed. Monolingual English children served as a control group to see whether FI student's L1 is being swayed by their L2. The overall number of tokens produced by FI children and monolingual English children can be found in Tables 8, 9, and 10.

Table 8. Number of tokens produced by FI children in their French speech production separated by grade and plosive.

	Grade 1	Grade 3	Grade 5
/p/	198	135	171
/t/	196	135	169
/k/	194	135	171
/b/	187	133	165
/d/	192	134	171
/g/	184	129	166

Table 9. Number of tokens produced by FI children in their English speech production separated by grade and plosive.

	Grade 1	Grade 3	Grade 5
/p/	196	133	170
/t/	194	135	171
/k/	196	135	169
/b/	195	135	170
/d/	189	134	170
/g/	198	135	171

Table 10. Number of tokens produced by monolingual English children in their English speech production separated by grade and plosive.

	Grade 1	Grade 3	Grade 5
/p/	135	169	89
/t/	135	165	90
/k/	133	167	90
/b/	133	164	90
/d/	135	166	90
/g/	135	162	90

2.4.1 Overall analysis of FI students

A single overall repeated measures ANOVA with the within-subject factors consonant (p, b, t, d, k, g) and language (English vs. French) and between subjects factor grade (1, 3, 5) was used to provide a comprehensive picture before partitioning the analysis. Results yielded a main effect of language (F (1, 31) = 15.77, $p < .001$), a main effect of initial stop consonant (F (5, 251) = 263.32, $p < .001$), and an interaction between language and initial stop consonant (F (5, 265) = 22.51, $p < .001$). These results suggest that as a whole, there is a significant difference between English and French VOT values in the speech production of FI students. Secondly, initial stop consonant is playing a significant role in VOT realizations which is most likely in large part due to the difference between voiced and voiceless phonetic categories. Lastly, when both language and initial stop consonant are taken into consideration together, they are interacting to significantly influence VOT values.

2.4.2 English vs. French

The first focus was to compare FI speakers VOT values in the two languages (English vs. French). In order to examine whether there would be an interaction between the two language systems in the VOT production of bilingual children for each word-initial stop, a series of individual repeated measures ANOVAs for /p/, /b/, /t/, /d/, /k/, /g/ were conducted. The dependent variable was VOT values produced by children and the independent variables were the cross-subject variable: Grade (1, 3, and 5) and within-subject variable: Language (English vs. French). Findings revealed a highly significant main effect of language for all voiceless stops: for /t/, (F (1, 53) = 112.92, $p < .001$), for /p/, (F (1, 53) = 80.53, $p < .001$), and for /k/, (F (1, 53) = 49.27, $p < .001$), reflecting the realization of shorter VOT values for French voiceless stops when compared to English voiceless stops. Table 11 and 12 display the mean VOT values produced by FI children. Post hoc tests were conducted to evaluate pairwise differences among the three grades. Follow-up Tukey tests determined that the main effect of language was present within each individual grade for all voiceless stops ($p < .01$), and across all grades for all voiceless stops ($p < .01$), with the exception of /t/ in grade 5 English compared to grade 3 French ($p = .113$). There was also a language by grade interaction for the voiceless stop /t/, (F (1, 53) = 3.88, $p = .027$) with a smaller language difference in grade 3 when compared to grade 1 and smaller in grade 3 when compared to grade 5. Likewise to the voiceless stops, a significant main effect of language was also present for the voiced stop /g/, (F (1, 53) = 9.17, $p = .004$). Pairwise post hoc comparisons did not reveal any differences between grades but nonetheless and interestingly, grades 1s showed the largest difference between the two languages with English /g/ being produced at 16.68 ms

VOT and French /g/ at 1.95 ms VOT; quite a substantial difference. These results indicate that students are maintaining a separation between their English and French VOT sound systems with no overlap manifesting between the two languages for all word-initial voiceless stops /p, t, k/ and for the word-initial voiced stop /g/.

Table 11. Means of VOT values (in milliseconds) and standard deviations in the French production of word-initial voiced and voiceless plosives produced by French immersion children.

	Grade 1		Grade 3		Grade 5		All Grades	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
/p/	63.8	30.7	60.7	26.3	57.7	25.8	60.7	27.6
/t/	64.5	28.5	75.9	34.6	68.2	20.9	69.5	28.0
/k/	86.3	34.9	84.1	25.5	81.1	24.7	83.8	28.4
/b/	0.4	45.9	-3.5	51.5	0.5	45.6	-0.9	47.7
/d/	-13.9	73.7	-2.2	64.5	-0.1	53.6	-5.4	63.9
/g/	16.7	50.6	14.1	54.1	13.9	50.1	14.9	51.6

Table 12. Means of VOT values (in milliseconds) and standard deviations in the English production of word-initial voiced and voiceless plosives produced by French immersion children.

	Grade 1		Grade 3		Grade 5		All Grades	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
/p/	82.2	31.7	83.0	28.9	75.2	21.3	80.1	27.3
/t/	91.8	29.1	92.3	29.7	84.2	27.1	89.4	28.6
/k/	100.6	30.4	101.6	29.4	92.7	26.6	98.3	28.8
/b/	-2.7	49.0	-9.2	55.5	-0.1	48.1	-4.0	50.9
/d/	-4.4	59.3	-9.0	61.3	-0.8	57.9	-4.7	59.5
/g/	1.9	63.2	5.3	57.0	8.1	60.4	5.1	60.2

2.4.3 Age related differences

In order to determine whether there exists a difference across the three grades (1, 3, and 5) in the French productions of FI children for each word-initial stop, again a series of individual repeated measures ANOVAs for /p/, /b/, /t/, /d/, /k/, /g/ were carried out. The dependent variable was French VOT values produced by children and the independent variable was the cross-subject categorical variable Grade (1, 3, 5). No significant differences in grades were revealed for each of the six stops. The absence of a main effect indicates that the VOT productions in children of the three age groups were not significantly different and thus no developmental age trend for each individual stop in regard to French VOT was noted.

2.4.4 French stop acquisition process

Given that there was no grade difference in French VOT values, all grades were collapsed together to examine the effect of stop on VOT unique to the French production condition. The dependent variable was VOT values produced by children and the independent variable was the within-subject factor stop consonant (p, b, t, d, k, g). As expected, there was a main effect of stop consonant ($p < .001$). Tukey post-hoc comparisons revealed that all stops were significantly different from one another ($p < .05$) with the only exception being for /b/-/d/. It has long been known that VOT varies with place of articulation beginning with Lisker and Abramson’s (1964) study. In their seminal study examining 11 different languages, results revealed that velar stops elicit longer VOTs than both bilabial and alveolar stops with bilabial stops yielding the shortest VOTs. Our results found support for this sequence with progressively longer VOTs beginning with /k/, intermediate in /t/ and shortest in /p/; the mean VOT for French voiceless velar /k/ was 83.8 ms, alveolar /t/ was 69.5 ms and voiceless bilabial /p/ production was 60.7 ms. Subsequently, we examined stop by grade to see if there is a developmental acquisition process in regard to which stops might be acquired first. Results revealed no interaction between grade and stop consonant (p = .593). These results indicate that the VOT patterns for plosives are similar across grades, demonstrating that a plosive developmental acquisition process was not present. Similar to a study conducted by Harada (2007), investigating the production of VOT by English speaking children in a Japanese immersion program, our results do not show a developmental acquisition process in regard to grade, or grade by stop consonant. In other words, FI students in grade 1, 3, and 5 showed similar duration of VOTs for all the stops.

2.4.5 Monolingual vs. FI

Lastly, we aimed to investigate whether FI students' English VOT productions differed from those of Monolingual English students. We performed a repeated measures ANOVA with the within-subject factor as initial stop consonant (p, b, t, d, k, g) and between subjects factors group (monolingual, bilingual) and age (6, 8, 9-11). As expected, results yielded a main effect of initial stop consonant (F (5, 475) = 371.96, p < .001). There was no effect of group or age and there were no interactions. However, when we ran separate repeated measures ANOVAs for each stop, a marginal significance emerged in the production of the voiceless stop /t/ between monolingual English and FI speakers' English (F (1, 95) = 3.763, p = .055) with the monolinguals mean VOT values of shorter duration for /t/ than the FI children. Table 13 displays monolingual English children's mean VOT value breakdown. Figure 10 depicts the English and French mean

VOT values produced by FI children along with the English mean VOT values produced by monolingual English children. These results reveal that monolingual and FI students are behaving similarly in their realization of voiced and voiceless stops with the exception of a marginal difference in the production of /t/. Furthermore, the FI children's English production shows no indication of being colored by their French. If anything, when we visually inspect Figure 10, FI students are actually further projecting their English voiceless VOT values in a more positive direction when compared to monolingual English children, although not significant. This over realization may be facilitating their L1 and L2 language separation providing support for Flege's (2003) "phonemic category dissimilation" hypothesis.

Table 13. Means of VOT values (in milliseconds) and standard deviations in the English production of word-initial voiced and voiceless plosives produced by monolingual English children.

	Grade 1		Grade 3		Grade 5		All Grades	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
/p/	73.4	31.6	75.1	28.5	73.9	26.5	74.1	28.9
/t/	83.7	30.2	82.1	37.6	80.6	19.9	82.1	29.2
/k/	93.4	33.2	93.2	31.3	89.3	24.9	92.0	29.8
/b/	-3.9	49.5	2.4	33.2	8.3	30.4	2.3	37.7
/d/	-6.4	65.3	-11.9	60.1	-5.0	60.3	-7.8	61.9
/g/	-0.1	67.3	5.1	52.7	15.7	48.2	6.9	56.1

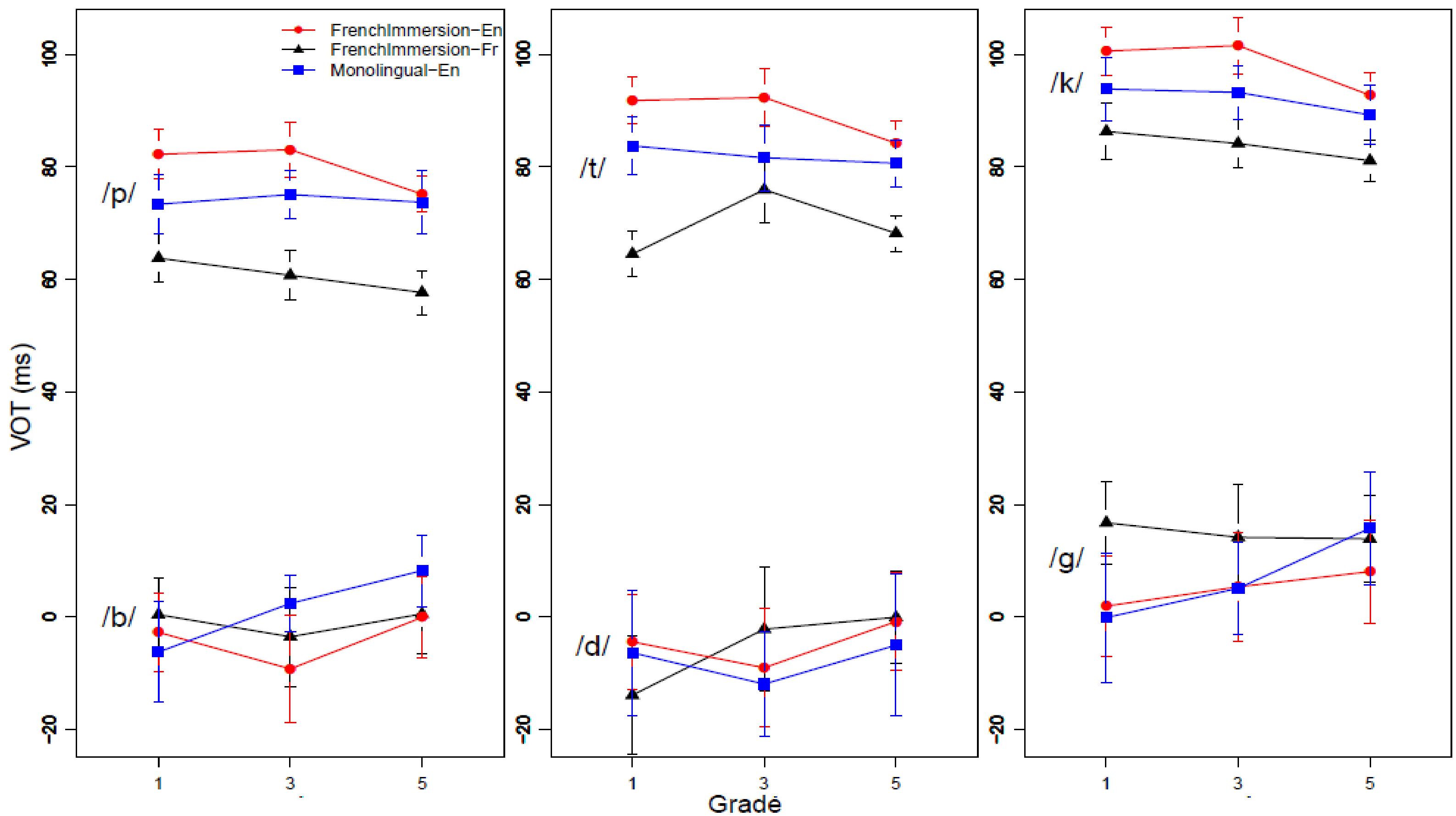

Figure 10. FI and monolingual English children's production of word-initial voiced and voiceless stops in both English and French. For each grade, the symbols represent the mean VOT values and the bars indicate 95% confidence interval.

2.5 Discussion

The production task was employed to examine FI students' realizations of voiced and voiceless stop consonants. Results demonstrated that there was no effect of age, indicating that FI students in grade 1, 3, and 5 showed similar duration of VOTs for all French stops. When collapsing all grades together and aggregating mean VOT values, the voiceless stops /p/, /t/, /k/ were produced in the long-lag VOT region whereas the voiced stops /b/, /d/ were found to be lead-lag, albeit only slightly prevoiced and voiced stop /g/ was realized with short-lag VOT. When comparing the two language systems of the FI children in terms of their VOT productions, it was evidenced that they are forming separate voicing categories between their two languages (English, French) for all voiceless stops /p/, /t/, /k/ as well as for the voiced stop /g/. On the other hand, the voiced stops /b/, /d/ did not yield any significant differences between the English and French VOT productions, evidencing that an interaction between the two sound systems is manifesting in the production of these voiced stops. Lastly, the FI students did not exhibit any significant differences in their voiced and voiceless plosive productions when compared to monolingual English children. This finding suggests that FI students' L1 is not being swayed in the direction of their L2. On the contrary, in terms of the voiceless stops, the L1 was found to project in the opposite direction of the L2 toward an increased long-lag VOT, likely accommodating a separation between the English and French language systems.

Chapter Three:

Experiment 2-Speech Perception

3.1 Overview

Not only does the speech production of an L2 learner relay valuable L2 acquisition information, speech perception bears equal relevance. The rich speech stream carries a number of acoustic cues pertinent to speech perception with VOT being just one of those cues. Children and adults tend to perceive speech sounds categorically, permitting listeners to make important distinctions between voicing categories. It is through the acoustic measure of VOT that voicing category differences are perceived. Cross-linguistic research suggests that listeners will perceive speech sounds differently based on the language(s) they have been exposed to (e.g. Christensen, 1984). Moreover, attunement to language specific categories sharpens with age and exposure (Hazan & Barrett, 2008; Medina, Hoonhorst, Bogliotti, Serniclaes, 2010). Previous research has shown that infants are born with the incredible ability to discriminate different languages of the world (Eimas, Siqueland, Jusczyk, & Vigorito, 1971; Werker & Tees, 1984). This extraordinary ability was first confirmed by Eimas and colleagues (1971) through a high amplitude sucking paradigm in which infants increased their sucking rate in response to a stimulus shift of differing phonemic VOT categories and then followed up by Werker and Tees (1984) through the conditioned head turn procedure. However, such innate discriminatory abilities in infants are only suggestive of auditory perceptual acuity but not category recognition, where the latter requires years of linguistic experience in a specific language milieu to form.

Two commonly accepted methods employed to investigate speech perception are discrimination and identification tasks. The former involves the listener responding to whether a sound token is the same or different than another, whereas the latter requires the listener to associate a speech stimuli to a label (e.g. pictorial). Language-specific categories such as voiced and voiceless stops can be examined via discrimination and identification tasks. VOT proves to be a very useful language research tool, as it can be manipulated to range on a voicing continuum in order to investigate specific acoustic parameters such as perceptual *boundary location* and perceptual sensitivity as determined by the *slope identification* function, enabling cross-language comparisons. *Boundary location* is the point at which a listener makes the shift between two phoneme categories (e.g. between /b/ and /p/) with this point varying from language to language. For example, Caramazza et al. (1973) report the boundary of the /p-b/ contrast at the 50% crossover point of monolingual English listeners to be located at 24 ms VOT, whereas monolingual French listeners exhibited a shorter VOT duration at 8 ms (see Table 14). Interestingly, Caramazza et al. report that bilingual speakers' boundary locations were different from those of monolinguals, falling at 19 ms (French) and 17 ms (English). In addition to boundary location, the *slope identification* function conveys useful information to speech researchers in that it corresponds to the rate of change in the perception of one category to another (Morrison, 2007). This identification function coincides with boundary precision where a steeper slope reveals more precise identification (Simon & Fourcin, 1978).

Table 14. Minimal pair mean VOT boundary locations (in milliseconds) at the 50% crossover for monolingual Canadian English speakers and monolingual Canadian French speakers (Caramazza et al., 1973).

	/p-b/	/t-d/	/k-g/
English	24	25	38
French	8	21	14

Not surprisingly, Flege (1989) asserts that more salient auditory perceptual cues will be easier for L2 learners to perceive than those that are not as easily detected. As mentioned previously (section 1.4.1), it has been suggested that aspiration may be a more easily identifiable cue than prevoicing (Aslin et al., 1981; Vanlocke & Simon, 2011). Correspondingly, lead VOT may pose more difficulty to L2 learners, particularly when this is a novel category in an L2 learner's already established VOT repertoire. Researchers acknowledge that it is not uncommon for L2 learners to have difficulty in establishing all of the appropriate sound differences in a non-native language (e.g. Goto, 1971; Flege, 1988). Interestingly, such indistinctness has not only been revealed in L2 learners, but also in native speakers' perception. Caramazza and colleagues (1973) report that the monolingual Canadian French participants examined in their study demonstrated perceptual uncertainty in a labelling task, therefore the authors posited that VOT did not prove to be a valuable acoustic cue for the Canadian French listeners. Assuming this is also the case for FI children, we might expect their French perceptual VOT function to be unstable when compared to their English perceptual function. If such a finding surfaces, however, the difficulty that arises in the interpretation is whether such an observation would be attributed to L2 learning or the general pattern noted by Caramazza et al. in regard to the Canadian French language.

3.2 The Present Experiment

In this experiment, we aimed to examine the speech perception of FI children by administering an identification task that applied a series of VOT edited stimuli differing on a voicing continuum between voiced and voiceless phonemic contrasts. Three monosyllabic consonant vowel (CV) minimal pairs consisting of labial /p-b/, alveolar /t-d/, and velar /k-g/ initial stops were examined. Specifically, the purpose of this experiment was to address whether developmental differences would be observed between FI children of different age groups, and whether children demonstrate identification functions appropriate for each language (English and French). In addition, FI students English identification function (e.g. boundary location) was compared to monolingual English children to determine whether FI children’s L1 is being influenced by their L2.

3.3 Methods

3.3.1 Participants

3.3.1.1 FI participants

Our original sample size was of N = 61, which included one extra participant from that of the speech production experiment, as the individual opted not to partake in the production task. From the total corpus of N = 61, five participants were removed for continuously clicking on the same pictures across minimal pairs in the French experiment. The experimenter had taken notes of these students completely neglecting one image from each of the 3 minimal pairs, during either the first half of the experiment, the second, or across both. Data analysis further confirmed that these children had slope coefficients close to zero or equal to zero. 56 cases were left for analysis after exclusion, with the same distribution of students per grade as the previous task (18 grade one, 18 grade three, 20 grade five). See Table 15 for FI participants' mean age and standard deviation breakdown. All 56 participants took part in the /p-b/ categorical perception component, explained in detail below. For the /t-d/ and /k-g/ phonemic contrasts, only grades 3 and 5 participated, for a total of 38 cases. Grade 1 FI children performed in a simplified 2 forced-choice identification task that did not comprise of the complete set of perception stimuli because not all grade 1 children were familiar with all six speech perception tokens (explained further in section 3.3.3). Recruitment and participation criteria are the same as in experiment 1.

Table 15. FI children's mean age in years and standard deviation separated by grade and sex.

	Grade 1	Grade 3	Grade 5
Males	$N = 6$ $M = 6.79$ $SD = 4.84$	$N = 5$ $M = 8.56$ $SD = 4.81$	$N = 9$ $M = 10.52$ $SD = 1.61$
Females	$N = 12$ $M = 6.66$ $SD = 4.31$	$N = 13$ $M = 8.76$ $SD = 3.61$	$N = 11$ $M = 10.58$ $SD = 4.83$
Total	$N = 18$ $M = 6.70$ $SD = 4.41$	$N = 18$ $M = 8.70$ $SD = 4.01$	$N = 20$ $M = 10.55$ $SD = 3.67$

3.3.1.2 Monolingual participants

The majority of the monolingual English children participated in both the production and the perception experiments. However, an additional 8 participants were included in the perception experiment. Fifty-four children (29 female, 25 male); 17 six year olds (8 female), 26 eight year olds (16 female), and 11 nine year olds (5 female) served as a monolingual English control group. See Table 16 for participants' mean age and standard deviation breakdown. Recruitment and participation criteria are the same as experiment 1.

Table 16. Monolingual English children's mean age in years and standard deviation separated by grade and sex.

	Grade 1	Grade 3	Grade 5
Males	$N = 9$ $M = 6.63$ $SD = 1.91$	$N = 10$ $M = 8.53$ $SD = 3.85$	$N = 6$ $M = 9.33$ $SD = 4.19$
Females	$N = 8$ $M = 6.52$ $SD = 4.65$	$N = 16$ $M = 8.57$ $SD = 2.91$	$N = 5$ $M = 9.63$ $SD = 4.82$
Total	$N = 17$ $M = 6.58$ $SD = 3.43$	$N = 26$ $M = 8.55$ $SD = 3.23$	$N = 11$ $M = 9.46$ $SD = 4.64$

3.3.2 Stimuli

For each of the three minimal pairs (/p-b/, /t-d/, /k-g/), 15 tokens were created from natural speech. Recordings were made with a Shure SM87A microphone at a sampling rate of 48000 hertz using a Marantz flashcard recorder (model: PMD661). For the French component, a native female French speaker produced six tokens consisting of three minimal pairs: *poule-boule, touche-douche, cou-goût* and for the English component a native female English speaker produced six tokens consisting of the three minimal pairs: *pear-bear*, *tear-deer*, *and coat-goat*. Stimuli were edited in Praat software (Boersma & Weenink, 2013) to range on a 15 member VOT continuum from -70 ms to +70 ms with 10 ms steps. This allotment of VOT was chosen because as noted by Medina et al. (2010), the voiced vs. voiceless distributions are larger in French than in English. In addition, approximately 10% of the stimuli were added as repetitions to gauge intra-subject reliability. The four repetitions included in the French experiment were: /k-g/ with a VOT of 60 ms and 10 ms, /t-d/ with a VOT of -50 ms, and /p-b/ with a VOT of -20 ms and in the English experiment: /t-d/ with a VOT of 60 ms and 10 ms, /p-b/ with a VOT of -20 ms and /k-g/ with a VOT of -50 ms.

Sound stimuli of all 3 pairs were randomized over the trials for a total of 45 experimental tokens. Manual editing for the sound stimuli was generated from natural speech using a progressive cross-splicing technique (similar to: Andruski, Blumstein, & Burton, 1994; McMurray, Aslin, Tanenhaus, Spivey, & Subik, 2008; Newman, 2003). All editing was done at the zero crossing of the waveform. The cross-splicing technique was applied to both the English and the French sound stimuli, following the same manual editing procedure for both languages with the only difference residing in the VOT duration of the original audio files, where any aspiration was removed before proceeding. Sound stimuli were created by successively removing the burst and VOT in approximately 10 ms increments from the original audio file of the voiced token /b/, /d/, /g/ and then replacing the cut sections with the corresponding duration of the voiceless token /p/, /t/, /k/. For instance, in creating the *bear-pear* continuum, the natural speech recording of '*pear*' was used as an extraction token. In order to create the first sound stimulus, the release of the oral occlusion /b/ was cut from '*bear*' (0 ms VOT baseline) and replaced with the /p/ release from the original '*pear*'. The second through eighth stimuli were then generated through the fusion of progressively larger portions of aspiration in approximately 10 ms increments until a +70 ms VOT was reached. In order to generate the negative VOT values, prevoicing slices in an increment of 10 ms were taken from a prevoiced 'bear'. The first negative VOT value was produced by inserting

10 ms of lead voicing to the left of the burst of the 0 ms VOT ‘bear’. The following six prevoiced items were created by sequentially adding 10 ms increments of negative VOT to the last edited item of ‘bear’ until -70 ms VOT value was reached.

3.3.3 Procedure

In order to examine the children’s speech perception, a forced-choice identification task was administered including the three phonemic contrasts: /p-b/, /t-d/ and /k-g/. French and English sessions were performed on different days. Stimuli were played over a speaker connected to a computer in a quiet room using the program E-Prime v 2.0 (Schneider, Eschman, & Zuccolotto: Psychology Software Tools, Pittsburgh, PA). During the task, children sat in front of a computer, and six images (for grades 3 and 5) or two images (for grade 1) associated with the target words appeared on the computer monitor, while a natural manipulated speech token simultaneously played over the speaker (Logitech Z205, model: S-00094 used for the FI group; Edirol MA-7A used for the monolingual English group). Refer to Appendix E for a depiction of the experimental paradigm. After the presentation of the stimuli, a fixation cross would appear in the centre of the computer screen for 2000 ms until the next stimuli were presented. Visual stimuli were counterbalanced across participants as well as half way through the experiment. Participants were offered a break halfway through testing. Before commencing the French perception experiment, children were first shown the images that they would be working with and an English-French bilingual speaker ensured that the students were able to name each experimental item before proceeding. After picture naming was completed, children were provided with verbal instructions of the task. They were told that they would hear a word over the speakers, while at the same time, six pictures (for grades 3 and 5) would be shown on the computer display and they were instructed to use the computer mouse to click on the matching image of the word that they heard. Prior to the to the experimental condition, a practice trial with all unedited original sound stimuli (6 tokens) was carried out so that the experimenter could make certain that the participant was accurate in responding (i.e. clicking on the correct corresponding image). A six-choice identification task was opted for given that during a pilot study this method demonstrated to be very effective in averting boredom and maintaining concentration. Moreover, this experimental design would allow researchers to take note of any students who were clicking haphazardly (i.e. clicking on images from an incorrect stop category or continuously clicking on the same image). Grade 1 FI children performed in a simplified 2 forced-choice identification (poule-boule for French and pear-bear for English) because during a pilot study, it was found that not all grade 1 children were familiar with the 'goût' and 'douche' tokens.

3.3.4 Intra-subject reliability

In addition to the participants who were removed prior to performing statistical analysis due to haphazard mouse clicking, another student was removed from the French analysis of the /t-d/ contrast for a slope coefficient of zero. For the English component, participants were required to achieve 50% or greater on both the intra-subject reliability measure (repetition tokens) and extreme value measure, where -70 ms VOT and +70 ms VOT were considered as extreme values. It was decided not to remove any FI students' French perception data for intra-reliability reasons unless noted by the experimenter that the student's identification responses were random; as mentioned previously, 5 students were removed for this very reason along with one additional student after observing their slope coefficient to be zero. The rationale behind the decision of not implementing the intra-subject reliability measure for the French perception task is that FI students are learning an L2 and so it is plausible that they may not always perform with high accuracy. Moreover, if we were to exclude students in regard to this parameter, we would be biasing towards the stronger French learners which is not a true representation of L2 learning in FI schooling.

3.4 Results

In analyzing the speech perception of FI students, the first objective was to determine whether a developmental trend would emerge across grades (1, 3, 5) in the French perceptual identification function. Next, the inclusion of FI students' English identification function served to address whether the French and English perceptual systems are appropriate for each language in addition to examining whether FI students exhibit a difference between their L1 and L2 perceptual abilities. Lastly, a comparison was made between the FI children's English identification function to that of monolingual English children to see whether the two groups behave similarly. In what's to follow, the findings of the FI students' French identification function are reported in terms of response frequency, slope parameters, and boundary location in relation to age for all minimal pairs.

3.4.1 Age related differences

The following statistical analyses were conducted to examine whether differences across grades 1, 3, and 5 would be revealed in French perception abilities.

3.4.1.1 Response frequency

First, in order to investigate the difference between grades in response frequency across voiced and voiceless categories in the children's French perception, a chi-square test was conducted for each minimal pair. For each minimal pair contrast, the dependent variable was response (e.g. 'p' or 'b') and the independent variable was grade (1, 3, 5 for /p-b/; 3, 5 for /t-d/ and /k-g/). A non-significant chi-square was obtained for all pairs: for /p-b/, χ^2 (2, N = 903) = .296, *p* = .862; for /t-d/ χ^2 (1, N = 566) = .130, *p* = .718; for /k-g/ χ^2 (1, N = 615) = .708, *p* = .400. These results indicate that the grade levels are behaving similarly in regard to response frequency across voiced and voiceless categories for each minimal pair.

3.4.1.2 Slope

Next, we wanted to compare the slopes of the identification function for each minimal pair across the age groups to examine the effect of age on L2 French perception abilities. More specifically, does the slope become steeper as the amount of French exposure increases? To extract a slope coefficient, for each of the three phonemic contrasts, we performed a binary logistic regression for each individual student. After obtaining a logistic slope value for each student, we were able to perform statistical analysis to evaluate whether the French slope coefficient differs as a function of grade. Firstly, a one-way ANOVA was conducted for the /p-b/ minimal pair with the assignment of slope coefficient as the dependent variable and between subjects factor grade (1, 3, 5) as the independent variable. No significant differences were found in the slope coefficient between grades 1, 3, and 5, χ^2 (2, N = 56) = 1.435, *p* = .247. To investigate age related differences in the perception of the /t-d/ and /k-g/ contrasts between grades 3 and 5, two separate t-tests were performed. No significant difference was found in the slope coefficients across grades 3 and 5 for /t-d/, t (36) = -.509, p = .614 (2-tailed, equal variance assumed), or for /k-g/, t (37) = .979, p = 334 (2-tailed, equal variance assumed). Taken together, no differences across age groups were revealed in the slope coefficient for labial, alveolar, or velar stops.

3.4.1.3 Boundary location

To assess differences across grade levels in the boundary location exhibited by children's French identification responses at the 50% crossover point for each minimal pair, we applied a natural logarithm and divided each individual child's intercept by its slope coefficient to obtain each individual child's boundary location. We then submitted the French boundary locations to three separate statistical analyses. Both the /p-b/ and /t-d/ boundary location data for grades 3 and 5 did not show a normal distribution, so non-parametric statistical tests were applied. A Kruskal-Wallis test was used to evaluate whether the French boundary location of the p-b pair differs as a function of grade (1, 3, 5). No significant difference was found in the distribution of VOT values of the French boundary location χ^2 (2, N = 56) = 1.04, p = .595. A Mann-Whitney U test was conducted to evaluate whether the French boundary location of the t-d pair differs significantly between grade 3 (n = 18) and grade 5 (n = 19). No significant difference was found in the distribution of VOT values across grades, z = -.664, p = .525. Lastly, a t-test was conducted to determine whether the French boundary location of the k-g pair differs as a function of grade (3, 5). No significant difference was found in the French VOT boundary location across grades, t (37) = .971, p = .338 (2-tailed, equal variance assumed). Similar to the findings of the slope parameter, the boundary location results indicate that there is no developmental pattern for boundary location in the students' French perception identification functions.

3.4.2 English vs. French

The statistical analyses reported here were conducted to determine whether the L1 and L2 perceptual systems of FI children are appropriate for each language and whether a significant difference between the two language modes would be revealed in FI students' identification functions.

3.4.2.1 Response frequency

In order to determine whether there would be a significant difference in the number of responses made for voiceless stops /p/, /t/, /k/ when compared to the identification of voiced stops /b/, /d/, /g/ as a function of language (English, French), separate McNemar tests were conducted for all minimal pairs. Results revealed that response type differed significantly by language between voiced and voiceless stops. The *voiced* plosives yielded significantly more identification responses in English than in French, $p < .001$ for all minimal pairs. These results provide support for a difference in boundary location between the two languages with the voiced stops being identified at a smaller VOT in French than in English. Moreover, to a certain extent, the results may also reflect the difficulty FI children are encountering in accurately identifying French voiced stops.

3.4.2.2 Slope

Individual paired-samples t-tests were carried out for each minimal pair to determine whether the slope coefficient in the categorical perception of the FI students was significantly different between their English and French performance. 56 participants were included in the /p-b/ analysis. Mean slope coefficient for the English condition was 2.83 (0.95 SD) compared to the French condition 1.92 (1.51 SD). Results showed that the slope coefficient for the French condition was significantly shallower than for the English condition, t (55) = 3.862, p <.001 (2-tailed). For the /t-d/ contrast, 37 participants were included in the analysis. Mean slope coefficient for the English condition was 2.64 (0.99 SD) compared to the French condition 2.30 (1.40 SD). Results determined that the slope coefficient for the French condition was not significantly different than that of the English condition, t (36) = 1.096, p = .280 (2-tailed). For the /k-g/ contrast, 38 participants were included in the analysis. Mean slope coefficient for the English condition was 2.80 (.86 SD) compared to the French condition 1.94 (1.47 SD). Results showed that the slope coefficient for the French condition was significantly shallower than for the English condition, t (37) = 3.130, p = .003 (2-tailed). For both the /p-b/ and /k-g/ contrasts, a significantly shallower slope parameter in the French component was observed, whereas the /t-d/ slope coefficient between the children’s English and French perception was not significantly different.

3.4.2.3 Boundary location

Next, the difference in boundary location between the English and French identification functions of the FI students was examined. Given that there was no difference across grades for boundary location, all grades were collapsed into one analysis for each minimal pair. Data did not show a normal distribution so a Wilcoxon test was employed separately for each minimal pair to determine whether there exists a difference between the English and French boundary locations at the 50% crossover point in the perception of the voiced and voiceless tokens. Results demonstrated a significant difference between English and French boundary location for all minimal pairs. For the /p-b/ pair, results yielded a significant shift in the positive VOT direction for the English identification function, Z = -6.57, $p < .001$ (2-tailed). For the /t-d/ pair, again the results indicate a significant shift in the positive VOT direction for the English identification function, Z = -5.37, $p < .001$ (2-tailed). Similar to both the /p-b/ and /t-d/ pairs, the perception of /k-g/ showed a shift in the positive VOT direction for the English identification function, Z = -5.36, $p < .001$ (2-tailed). These results indicate that children are forming distinct boundary locations for each language and that the English boundary for all minimal pairs is located in the higher positive range of the VOT continuum than the French boundary location.

3.4.3 Monolingual vs. FI

Monolingual English children served as a control group in the speech perception experiment in order to investigate whether FI children are comparable to FI children in their English perception abilities in regard to boundary location and slope coefficients. Such a comparison would allow for us to examine if the FI students' L1 has been affected by their L2 in terms of the perceptual identification function.

3.4.3.1 Boundary location

T-tests were performed for both the /t-d/ and /k-g/ contrasts where FI students' English boundary location at the 50% crossover for each minimal pair were compared to that of monolingual English children. Data for the /p-b/ contrast was not normally distributed so a Mann-Whitney U test was conducted. For /t-d/, grades 3 and 5 were combined as no age related differences were observed. The mean boundary location of /t-d/ for the monolingual English children (n = 37) was located at 50.81 ms, SD = 9.01 and for the FI children (n = 37), 48.41 ms, SD = 8.19. The t test was not significant, t (73) = 1.198, p =.235 (2 tailed, equal variance assumed). For /k-g/, again grades 3 and 5 were combined and the mean boundary location for the monolingual English children (n = 37) was located at 39.32 ms, SD = 12.78 and for the FI children (n = 38), 36.52 ms, SD = 9.40. The t test was not significant, t (66.05) = 1.078, p =.285 (2 tailed, unequal variance assumed). For /p-b/, grades 1, 3 and 5 were combined and a Mann-Whitney U test was performed. Mean boundary location for the monolingual English children (n = 54) was 28.07 ms (SD = 9.45) and for the FI children (n = 56), 27.28 ms (SD = 6.86). Similar to the other minimal pairs, results revealed no significant difference in the boundary location of monolingual and FI children, U = 1 341.50.0, p = .200 (2 tailed). In sum, monolingual English children and FI children exhibited fairly similar boundary locations and no significant difference between the two groups was revealed.

3.4.3.2 Slope

To examine whether FI children and monolingual English children differ in their English slope coefficients, Mann-Whitney U tests were performed for each minimal pair. For /p-b/, grades 1, 3, and 5 were combined. FI students showed a difference between grade 1-3 and 1-5 in their English slope coefficient but considering the focus of our paper is not on the FI children's English perceptual development, all grades were pooled together. Monolingual children did not show any age-related differences. There were 54 monolingual English cases included in the analysis, and 56 FI cases. For /p-b/, the mean slope coefficient for the monolingual English children was 2.63 (SD = 1.13) and for the FI children 2.83 (SD = .95). Results revealed no significant difference in slope coefficient between monolingual and FI children, $U = 1\,579.50$, $p = .790$ (2 tailed). Next, for /t-d/, grades 3 and 5 were combined with no age related differences observed. The mean slope coefficient for the monolingual English children (n = 37) was 2.61 (SD = 1.08) and for the FI children (n = 37), 2.64 (SD = .99). Results revealed no significant difference in slope coefficient for /t-d/ between monolingual and FI children, $U = 624.0$, $p = .503$ (2 tailed). For /k-g/, grades 3 and 5 were once again pooled together. Mean English slope coefficient for the monolingual English children (n = 37) was 2.62 (SD = 1.12) and for the FI children (n = 38) was 2.80 (SD = .86). Similar to the other minimal pairs, results showed no significant difference in slope coefficient between monolingual and FI children, $U = 757.50$, $p = .554$ (2 tailed). These results indicate that Monolingual English children and FI children between the ages of 6 and 11 do not differ in their slope coefficients of their identification functions of labial, alveolar, or velar English stops. Figure 11 depicts the identification function of FI and monolingual English children's perception of /p-b/, /t-d/, and /k-g/ in both English and French as a function of VOT.

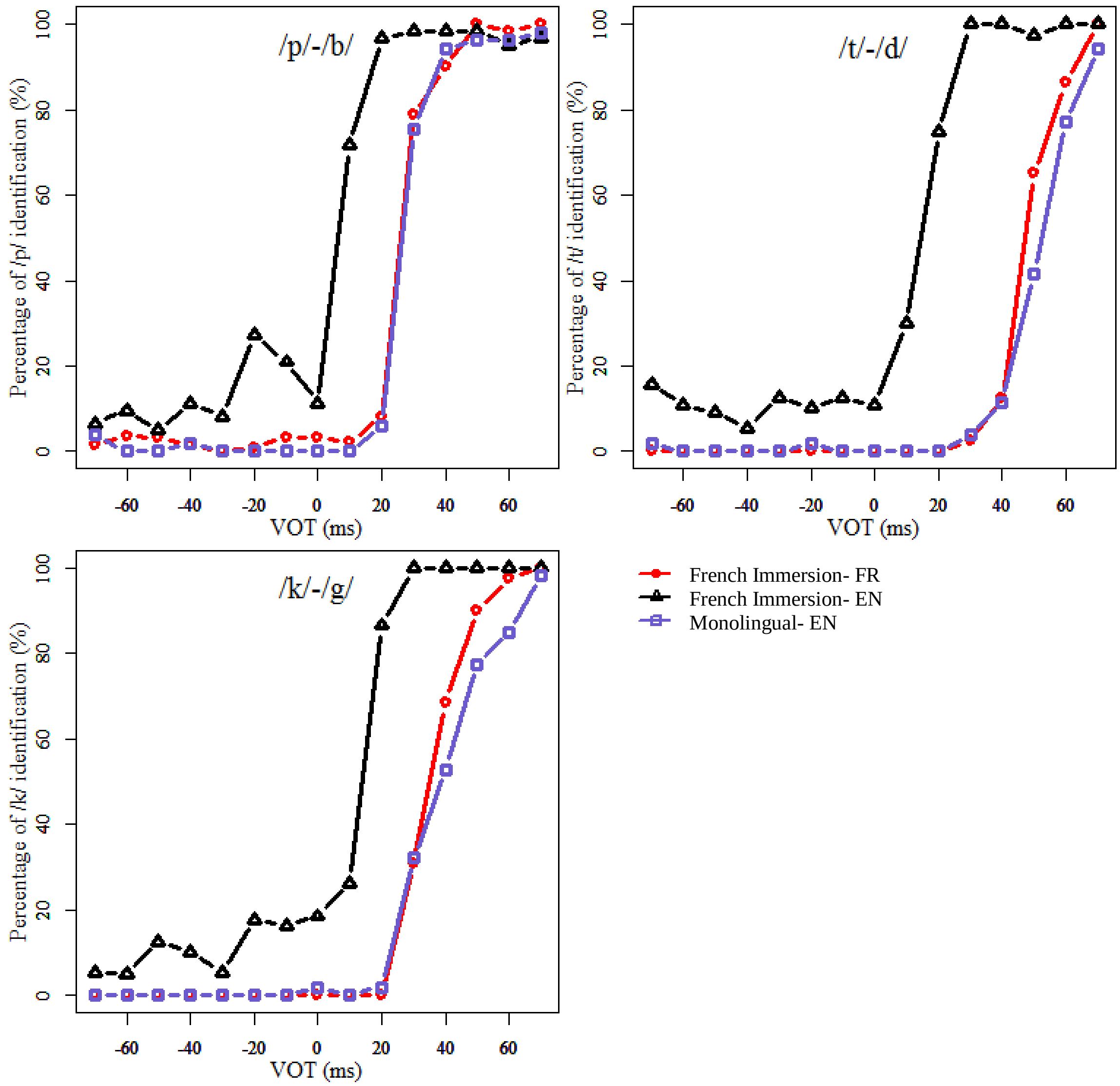

Figure 11. FI and monolingual English children's mean identification scores for the perception of /p-b/, /t-d/, and /k-g/ in both English and French as a function of VOT.

3.5 Discussion

Consistent with the findings from the production experiment, grades 1, 3, and 5 did not significantly differ from one another, with all three age groups demonstrating similar speech perception behavior. Next, in regard to the differences in the identification function between the two languages, English and French boundary locations exhibited by children's responses to the voicing contrasts were significantly different for all minimal pairs. Moreover, boundary locations were appropriate for each language indicating that FI students have formed language specific boundary locations in their distinction of voicing categories for each language mode. Pedagogically, this suggests that FI schooling is proving successful in facilitating native-like French boundary locations between voicing contrasts. However, even though FI student's French boundary locations are prototypical, it should be noted that FI students are having difficulty in correctly identifying voiced stops in French where are at times they are misidentifying these tokens as voiceless stops. Conversely, FI children did not show any difficulty in correctly identifying the French voiceless stops. In terms of the slope parameter, other than the alveolar pair /t-d/, FI students' slopes are significantly different between the two languages where their French slope is significantly shallower than that of their English. The slope parameter differences reflect the rate of change from one phonemic contrast to the next, with the change manifesting as rather abrupt in the English perceptual function when compared to the French. The significant difference in slope parameter between English and French might partly reflect the difficulty that children are having in the identification of French voiced stops. Lastly, FI students performed similarly to monolingual English children in all aspects of the English identification function.

Chapter Four: General Discussion

The present study served to explore the L2 phonetic development of native English speaking children learning French through an immersion program. This thesis was predicated on the lack of phonetic documentation in SLA reports of immersion schooling. In order to render a comprehensive account of VOT behavior exhibited by FI students, both the speech production and speech perception of children's' L1 (English) and L2 (French) was assessed through the administration of two separate tests: a word repetition task and a forced-choice identification task. By evaluating the VOT values elicited through FI students' voiced /b/, /d/, /g/ and voiceless /p/, /t/, /k/ plosive productions as well as the delineation of the VOT space in stop perception, it was possible to address firstly, whether a French developmental acquisition process would be observed in elementary school children. Grades 1, 3, and 5 were included in the present study to investigate whether a more native-like proficiency would translate as FI students advance through grades. Secondly, this thesis aimed to explore whether children are establishing two distinct sound systems between their L1 and L2. By examining both the English and French sound systems of the FI students, it was possible to determine whether the L2 learners are able to maintain two separate VOT systems between their L1 and their L2 in the production of voiced and voiceless stops and if not, in what direction the interference between the two language systems would manifest. Lastly, the abiding focus in SLA on the link between speech production and perception was addressed. Given that our research encompassed both of these developmental processes by the inclusion of two separate experiments it was possible to shed light on the nature of the relation between these two L2 learning components.

4.1 Experiment 1-Speech Production

4.1.1 Age related differences

With an increase in French experience as children advance from grades 1 to 5, it was predicted that an improvement in the direction of more native-like French VOT production patterns would be observed. However, this was not the case. Results of the first experiment evidenced that FI students of all grade levels were comparable in French VOT realization of plosives. Therefore, there was no indication of L2 VOT development in the French speech production of voiced and voiceless stops among FI students. The absence of L2 age-related developmental VOT variation suggests that the length of L2 exposure is not playing a leading role in the VOT performance of students enrolled in an FI program. Moreover, these findings indicate that a year exposure (kindergarten) and the first couple of months in grade 1 (when data collection began) of FI schooling is effective in guiding grade 1s to a similar level of grade 5s in terms of VOT realizations. Two previous immersion studies also report on a lack of improvement in immersion students' L2 speech production abilities throughout the course of the schooling years. For instance, in accordance with our results, Harada (2007) who investigated the VOT of English speaking students attending a Japanese immersion program, found no significant differences in Japanese VOT productions of stops /p/, /t/, /k/ across grade 1, 3 and 5. Similarly, a study conducted by Snow and Campbell (1983) revealed that L2 pronunciation reached its peak in grade 3 and was rated even higher than that of the grade 6 Spanish immersion students (as cited in Harada, 2007), however bearing in mind that this study employed subjective measures.

4.1.2 Comparison to Francophone speakers

Corresponding to the observation of non-existent age related differences, FI students did not progress toward the prototypical VOT realizations of native French speakers. This conclusion was drawn from a comparison between FI students in the present study to Francophone students residing in Quebec and France. Because we were not able to obtain VOT values from Francophone children in Southern Alberta, Canada, Table 2 in section 1.4.1 provides voiced and voiceless VOT values produced by Quebec Francophone children aged 7-9 (Ryalls & Larouche, 1992) and Table 3 provides the VOT values of France Francophone children aged 5-8 taken from a pilot study conducted by Scarbel, Vilain, Lœvenbruck, and Schmerber (2012). When we compare the French VOT values obtained in our study with the Canadian French VOT values of voiced and voiceless stops reported in Ryalls and Larouche, it is apparent that there is quite a disparity between FI students' French VOTs and Francophone children norm values, particularly in the production of voiced stops. It can be observed that Francophone children are realizing their French voiced stops with extreme negative VOT values whereas FI children are hardly even prevoicing, and for /g/ not at all.

One possible explanation for the finding that FI children are not producing heavy prevoicing in their French voiced stops might reflect the inherent articulatory difficulty that accompanies accurate lead-voicing in stop production (Kewley-Port & Preston, 1974; Macken & Barton, 1980). More specifically, the fact that lead voicing is for several L2 learners a novel voicing category, would require the development of newly learned complex articulatory manipulation in order to be produced accordingly. Prevoicing requires the vocal folds to begin vibrating before the release of the initial stop, thus involving a more demanding exertion of articulation (Westbury & Keating, 1986). In order to produce a prevoiced plosive, a number of physiological conditions must be met in terms of transglottal pressure manipulation and vocal fold adduction. Previous research investigating L1 acquisition has found that prevoicing is acquired latest of modal VOT categories (e.g. Allen, 1985; Khattab, 2000).

Along with the complex articulatory manipulation that is required for prevoicing, Vanlocke and Simon (2011) further points out that prevoicing is not as acoustically salient of a cue as aspiration. According to Flege (1989), articulatory properties that are not as easily detected, will be in fact more difficult to acquire. Moreover, and more specifically to the French language, a study conducted by Caramazza and colleagues (1973) found that monolingual Canadian French speakers rely less on VOT as an acoustic cue than do monolingual Canadian English speakers. The researchers examined the perceptual identification function of both groups of speakers, and the results evidenced that in the labelling of voicing distinctions, VOT was shown to be a significant perceptual cue for monolingual Canadian English speakers, whereas this did not prove to be the case for monolingual French speakers. The latter's perceptual identification slopes yielded inconsistency with a slow rate of change when compared to the former group who demonstrated steep identification slopes. These findings suggest that there might in fact be a difference in the degree of perceptual saliency and acuity of VOT between the two languages. Based on the assumption that VOT is not as salient a cue in French when compared to the aspirating language of English, it can be inferred that even if prevoicing is being accurately transmitted by French speaking models (i.e. FI teachers) in the FI classroom, students may nonetheless present with difficulty in perceiving this category, in turn it will follow that VOT production of voiced stops might be impeded.

Next, in terms of the French voiceless plosive category, when we compare FI students to Francophone children, FI students are still not hitting the mark, but to a much lesser extent than with the voiced plosives. The apical dental stop /t/ was the closest between the Francophone and FI students: 60 ms and 69.5 ms, respectively. It is worthwhile to note that although French has been described as a language contrasting prevoiced and short-lag stops, with the short-lag region typically ranging between 0-40 ms (Macleod & Stoel-Gammon, 2008), the VOT values of plosives /t/ and /k/ in the Francophone children obtained from Ryalls and Larouche (1992) and Scarbel et al. (2012) are not consistent with the French short-lag pattern reported in adult literature (See Caramazza et al., 1973; Fowler, Sramko, Ostry, Rowland, & Hallé, 2008 for VOT values). Rather, Francophone children are exhibiting an intermediate-lag voicing pattern. This may be due in part to the lack of stabilization in children's VOTs, but as they age it is likely that they will progress towards adult typical values. Notably, even in comparison to the intermediate (rather than short) French voiceless plosives VOT values reported in previous studies (e.g. Ryalls & Larouche, 1992; Scarbel et al., 2012) of Francophone children, which would in effect promote more of a grace way for FI students, FI students VOT realizations are still overshooting the target-norm.

The result of non-authentic French speech production near the end of elementary schooling is consistent with previous studies (e.g. Genesee, 1978; Swain 1984; Hammerley, 1991). Having said that, studies that have reported non-authentic French pronunciation in FI students did not utilize objective acoustic parameter measurements, thus the precise underlying account for inaccurate L2 pronunciation had yet to be extracted. Our results indicate that through VOT comparison with previous studies, (given that an Alberta Francophone control group was not used in our study) FI students differ considerably from Francophone children reported in the literature in terms of stop consonant production with the exception of the voiceless stop /t/. These comparisons lend to the observation that FI students are falling short in their French pronunciation abilities, revealing possibly, just one of the phonetic areas that this non-native-like proficiency is emerging.

Reports from previous studies and findings from this thesis suggest that accented speech in the L2 production of immersion students might be partly attributed to the minimal opportunity for output and the nature of the input received. As stated in earlier sections, FI teachers are not necessarily native French speakers. Bearing in mind the results obtained by Harada (2007), where Japanese immersion children were also found to fall short of native-like speech production in the L2; the sociolinguistic situation is rather similar when we compare Harada's immersion study to the present study. The author suggested that nature of the input from the bilingual teachers was likely to be playing a role in the ultimate VOT realizations of the early Japanese learners.

4.1.3 Monolingual English vs. FI

Upon comparing the monolingual English children of our study to the FI children's' English voiced and voiceless plosive productions, FI students did not prove to be significantly different. Interestingly, FI children even further lengthened their voiceless English VOT values beyond those of the monolingual English children, although not significant. This distinction suggests that the FI children are forming even more of a separation between their two language systems by overshooting their voiceless English stops. The analysis of the voiced stops revealed that similar to the FI students, monolingual English children are also exhibiting instances of free variation with instances of both slight prevoicing and short-lag VOT in the production of the voiced stops /b/, /d/, and manifesting more regularly with /d/. The comparison between monolingual English children and FI students voiced and voiceless production allowed for us to ascertain that a "phonetic drift" from the L1 in the direction of the L2 did not transpire given that both groups of speakers were comparable, therefore indicating that FI students' English VOT system is not being affected by that of their French system.

4.1.4 English vs. French

Despite the non-native-like French VOT production patterns observed in the L2 learners; our results indicate that FI children are capable of establishing separate sound systems between their two languages in certain respects. In the case of voiceless /p/, /t/, /k/ plosive production, the L2 learners did not exhibit phonetic transfer from their L1 to their L2 in which they had formed two distinct phonetic categories for both languages. This finding is significant because it is indicative of early FI schooling proving effective in facilitating sound system separation in the voiceless stop productions. Harada (2007) also found that the Japanese immersion students from his study did not attain target Japanese values but clearly separated their Japanese and English sound systems in the production of /p/, /t/, /k/. Moreover, the FI children examined in this thesis also distinguished their L1 and L2 systems in the production of the voiced stop /g/. Surprisingly, the FI students' mean French realization of /g/ exhibited an even longer duration of VOT than the mean English realization of /g/. These results are rather unexpected given that we would expect English /g/ to be of a longer VOT duration. Interestingly, /g/ is a velar stop that has been associated with aspiration at times during French speech production in French-English bilingual children (Watson, 1990). When this is the case the /g/ takes on more similar acoustic properties to /k/. When French /g/ is produced with aspiration and English /g/ is not then this facilitates phonetic spacing to emerge between the two language sound systems. Interestingly, this finding was particularly prevalent for grade 1. Worth mentioning is that, the majority of students who produced French /g/ in the more positive VOT range when compared to their English /g/ productions were from the same classroom. This finding is noteworthy as it may be indicative of the influence of the nature of input. In sum, children were successful in maintaining distinct phonetic language systems in the production of voiceless stops and the voiced stop /g/.

With that being said, phonetic language separation is not guaranteed wherein the production of the French voiced stops /b/, /d/ it is the case that interference from the L1 to the L2 emerged. The French production patterns observed in the realization of the voiced stops /b/, /d/ of the FI students are very similar to those of their English voiced stop realizations, indicating that children have not formed a discrete voicing category for their French voiced productions. While probing into possible explanations for the missed mark in phonetic language separation for /b/, /d/, it is pertinent to bring to the surface that English voiced stops exist in free variation. In other words, although they are generally produced as short-lag, it is also possible for them to be prevoiced in English. When examining FI students' English VOT realizations, voiced stops are being produced with slight lead voicing in some cases and short-lag voicing in others, characteristic of the free variation phenomenon observed in Canadian English. Likewise, their French tokens are being produced in a similar manner, with instances of both slight prevoicing and short-lag realizations where FI students are not exhibiting heavy prevoicing in their French voiced stop productions, thus hindering a separation between the two language sound systems. In the event that native English children are realizing their English voiced stops with negative VOT values, in order to facilitate a separation between the English and French languages, they would need to lengthen their French voiced stops in a more negative VOT direction.

FI students come to learn their L2 with an already established L1 system; this is known as sequential L2 learning. This type of language learning ensues with an already shaped phonological scheme for the first language. Subsequently, L2 learners will utilize their L1 phonological system in embarking on the unknown territory of SLA (e.g. Anderson, 2004). This mapping from the L1 to the L2 is well documented and has been coined as "language transfer". A longitudinal study conducted by Anderson (2004) examining phonological acquisition in preschoolers learning a L2 via immersion, found that children who are learning an L2 utilize their knowledge of L1 to help them in acquiring the phonological system of the L2. Results obtained from the Anderson study found that L1 was used to map onto the L2. However, mapping on to the L1 can evoke potential errors in both the grammatical and phonetic output of an L2 learner as observed in the present study. The errors that transpire due to the influence of one's native language is understood as L1 "interference" (e.g. Flege, 1995). Results from the production experiment in the present study lend to the notion that that the L2 learners are mapping on to their L1 in order to produce French voiced stops, resulting in 'compromised' French VOT values 'colored' by the native English speakers' already established L1 phonetic system.

4.2 Experiment 2-Speech Perception

4.2.1 Comparison to Francophone speakers

From hereinafter, all three age groups (grades 1, 3, 5) will be considered as whole given that no age related differences were observed in the speech perception abilities of FI students. Similar to the VOT production prediction, it was hypothesized that a developmental trend would be observed in the perceptual identification function of FI students. Given that this was not the case, the results of the speech perception experiment coincide with the speech production findings, where length of exposure to the L2 is not playing a prevailing role in the VOT performance of FI students. This again provides support for the effectiveness of the first year of FI schooling in leading grade 1 students to a similar level in regard to VOT perception abilities as grade 5 students.

In terms of perceptual abilities, for all three minimal pair contrasts, FI students generally demonstrated appropriate French boundary location identification. For the labial and velar minimal pairs: /p-b/ and /k-g/ respectively, FI students were compared with adult speakers (i.e. Caramazza et al., 1973) as Quebec French children's identification function data appears to be sparse. Caramazza and colleagues reported the /p-b/ boundary location of native Quebec French speakers to be of 8 ms VOT and for that of /k-g/ to be located at 14 ms (refer to Table 14 of section 3.1 for mean VOT boundary locations reported by Caramazza et al.). The approximate boundary locations observed in the French identification function of the FI students in the present study for /p-b/ fell at approximately 6 ms, and for /k-g/ around 15 ms, nearly the exact same values as those reported by Caramazza et al. The only boundary location that differed from previously reported literature was for the apical dental stop pair /t-d/. First, we compared our results for the /t-d/ contrast to those obtained from native Parisian French speaking children, adolescents and adults (grouped together given that no difference was revealed across the age groups), in Medina and colleagues' (2010) study. The authors found that the mean VOT boundary of native French speakers was located at 7.3 ms for /t-d/. Whereas, Caramazza et al. reported the /t-d/ boundary location of monolingual French speakers in their study to be located at 21 ms. There is quite a large disparity between these two reported values, likely owing to the difference in French dialects. Nonetheless, the FI children in our study exhibited an intermediate boundary location between those just reported, falling at approximately 15 ms at the 50% crossover. These results suggest that FI schooling appears to be proving effective in shaping students' categorical boundary locations, where in general, FI students are showing a remarkable ability in distinguishing the point along the French VOT continuum where a voiced stop (e.g. /b/) becomes a voiceless stop (e.g. /p/).

4.2.2 English vs. French

A within speaker statistical analysis was applied to provide a comparison of the FI students' English and French perceptual identification functions. A significant shift in boundary location between the students' English and French speech perception was revealed. This shift relocated toward a more positive VOT location for the English identification function for all plosive contrasts evidencing that the boundary locations exhibited in the FI students L1 and L2 were significantly different and appropriate for each language. As expected, the perception of the students' English voicing contrasts was more consistent than that of their French. Having said that, children did perform with high accuracy in their identification of the French voiceless tokens /p/, /t/, /k/. On the other hand, when it came to identifying the French voiced stops /b/, /d/, /g/, FI students demonstrated a certain degree of difficulty, where at times they misidentified French prevoiced tokens /b/, /d/, /g/ as French short lag /p/, /t/, /k/. Although FI student's French boundary locations were found to be language appropriate, it was observed that FI students are having difficulty in correctly identifying voiced stops in French where it is the case that at times these tokens are being misidentified as voiceless plosives. On the other hand, FI students did not exhibit any difficulty in correctly identifying the French voiceless stops.

Moreover, along the same lines as the boundary location results, a significant difference between the L1 and L2 slope functions for /p-b/ and /k-g/ was yielded, with the French slope being shallower. This finding may appear to be a bit misleading upon visual inspection of Figure 11 in section 3.4.3. In other words, the steepness of the slopes depicted in the identification function plots for /p-b/ and /k-g/ between English and French in the immersion children appear to be rather similar. However, when we consider that the /t-d/ perceptual contrast did not yield any significant differences between the L1 and L2 of FI children, an apparent difference emerges whilst comparing the /t-d/ plot to both the /p-b/ and /k-g/ plots; voiced stop identification was more consistent among the FI students' responses for the voiced stop /d/ (although still revealing a certain degree of confusion) when compared to that of /b/ and /g/. With that in mind, the slope parameter is also taking into account the discrepancy that is arising in the identification of the voiced stops, reflecting the difficulty that FI students are encountering in correctly identifying French voiced stops. These findings suggest that French voiced stops are posing a challenge for FI students as they are struggling with establishing a perceptual distinction between short-lag voiceless stops from voiced stops in their French perception. A similar finding was noted in late Italian-English speakers in a study conducted by Mackay et al. (2001) who investigated the perception of voiced and voiceless English stops in word-initial position. Similar to French and English, Italian and English also contrast between prevoiced and short-lag for Italian and short-lag vs. long-lag for English: Italian voiced stops /b/, /d/, /g/ are prevoiced and voiceless stops /p/, /t/, /k/ are realized as short-lag. The authors found that the late listeners tended to misidentify the short-lag English stops /b/, /d/, /g/ as /p/, /t/, /k/. Given that the Italian-English bilinguals were native Italian speakers, it appears that they were also struggling in the perception of a 'new' phonetic category, that of the long-lag contrast typical to English voiceless stops /p/, /t/, /k/.

Two cross-language models were put forth in section 1.2.5, to account for the difficulty that L2 learners may have in successfully acquiring a L2 speech sound. According to the CAH proposed by Lado (1957) and the SLM developed by Flege (1995), the degree of cross-language similarity between the L1 and L2 plays a key role in whether L2 speech sounds will be accurately acquired. Flege's working model postulates that the greater the phonetic dissimilarity between an L2 phoneme and its closest L1 phoneme, the more likely the L2 sound will be accurately perceived and produced. However, our results in fact yielded the opposite. Rather, the findings of our study provide support for the CAH, where difficulties will arise in ultimate L2 attainment when an L2 sound is most dissimilar to its closest L1 relative. Voiced stops in French are characterized by heavy prevoicing; a new L2 sound category for many native English speakers. French voiced stops (heavy prevoicing) are more dissimilar to English voiced stops (short-lag/slight-prevoicing) than French voiceless stops (short-lag) are to English voiceless stops (long-lag) typical to English.

4.2.3 Monolingual English vs. FI

In order to determine whether FI students' English perceptual function is being influenced by their L2, statistical analysis were conducted to compare the perceptual identification function of the Monolingual English control group to that of the FI students'. No significant difference between the two groups was observed in boundary location or slope identification. These findings indicate that FI students' English VOT perception boundary locations are not being swayed in the direction of the French VOT boundary locations given that they are similar to monolingual English children. Moreover, FI students did not show any perceptual difficulties in terms of the accuracy of their responses in the identification of voiced and voiceless categories in their English perception. These findings further support previous immersion research that has claimed that the English language skills of FI students show no indication of attrition as a result of learning through the medium of an L2 in the immersion program.

4.3 A Link between Speech Production and Perception

The findings of this thesis provide support for a link between speech production and perception where FI students exhibited similar patterns between these two behaviors.

Two influential models have previously addressed this link: The assimilation model proposed by Best & Tyler (2006) and Flege's (1995) SLM hold that the production of L2 sounds may be inaccurate if they are not correctly perceived by the L2 learner. Flege has found support for this relationship in numerous studies (Flege et al., 1997; Flege, 1993; Flege, et al., 1999; Schmidt & Flege, 1995). The findings from our study provide support for this notion in the sense that FI students had no difficulty in correctly identifying the French voiceless stops where it was also the case that they established two separate sound systems in the production of the voiceless stops. Conversely, the L2 learners struggled in their identification of the voiced stop category and also demonstrated that they were unable to maintain two distinct sound systems in the production of the voiced stops, with the exception of /g/. Given that our results offer support to the proposed link between speech production and perception, it is reasonable to infer that the observed difficulty that arose in FI students' identification of voiced stops is likely hindering accurate VOT realizations in the speech production of this voicing category. The possible explanations that may account for this finding are reported in the next section.

4.4 Factors to Consider in the VOT Short-coming of FI students

Given that age of learning has been ascribed as one of the leading factors facilitating authentic L2 acquisition, as mentioned previously, one might have expected that early FI students would ultimately attain native proficiency in both speech production and perception. It was hypothesized in section 1.5.3.1 that FI children would not necessarily reach native-like speech production in regard to VOT patterns but that a progression toward more authentic French VOT values would be observed as children gained more experience with the L2. Given that this hypothesis was not confirmed, a detailed account of the larger socio-linguistic context and other key factors must be considered. It is important to bear in mind that the numerous factors that have been posited to influence the ease and proficiency at which an L2 is learned, do not operate in isolation. The dynamic interplay between age of learning, the quality of the L2 input, the opportunity for L2 output, length of exposure, daily uses of L1 and L2, the status of L1 and L2 in the society, and speakers' motivation and attitudes ought not to be discounted. Having said, the findings of the present thesis enable us to draw attention to what appear to be the most influential factors in SLA specific to a FI program. The five factors that appear to be playing prevailing roles in the L2 VOT acquisition of students enrolled in a FI program are: 1) the already intact L1 2) nature of L2 input 3) the larger social context 4) daily uses of L1 and L2 5) the opportunity for L2 output.

When native-like proficiency is not acquired in one's L2, particularly in early learners, various explanations have been posited. Firstly, the influence of the already established L1 phonological system may lead to difficulties in L2 acquisition where interference from the L1 to the L2 may be observed. L2 researchers often discriminate between simultaneous vs. sequential bilinguals. The former refers to the acquisition of two or more languages from birth, whereas sequential/consecutive bilingualism refers to the acquisition of another language after the L1 is already intact. Evidently, these two distinct types of bilinguals will come to learn their languages in very different ways. Unlike simultaneous bilinguals, sequential L2 learning ensues with an already shaped phonological scheme for the first language; subsequently children (e.g. FI students) will incorporate what they already know when learning a new language system, leading to potential errors.

In terms of the nature of L2 input, reported to bear weight in the ultimate realization of L2 sounds on numerous accounts, (e.g. Flege et al., 2003; Flege & Eefting, 1987; Harada, 2007; Khattab, 2000; MacKay et al., 2001), FI teachers may or may not be native French speakers. Therefore, we can infer that the nature of L2 input children are receiving in the classroom is most likely having a direct impact on the students' speech production patterns. The lack of authentic target French models in the classroom may impede L2 learning from approaching authenticity. If students are exposed to non-authentic output on a daily weekday basis, it would thus not be surprising that their VOT values may take on a similar pattern to the French models in the classroom setting. By the same token, French voiced stops for non-native French teachers may be a new voicing category characterized by heavy prevoicing where it may be the case that not even the teachers are realizing French voiced stops with negative VOT values. Secondly, classmates are at a similar L2 learning stage and their input is also *highly* influential.

When we evaluate the larger social context in Alberta, Canada, the most discernible observation is that it is an English dominant community. The influence of L1 dominant society is undoubtedly playing a role in FI children's L2 acquisition process given that L2 exposure only occurs in a finite context. Sound support for the influence of the sociolinguistic situation is brought to light by Beardsmore & Swain (1985) who compared two groups of students enrolled in French programs in two different countries: Canada and Brussels. The difference between the two L2 learning conditions resided in the fact that in Brussels the L2 was used both inside and outside of the classroom whereas in Canada, French was generally confined to the classroom setting. The authors reported that the Canadian FI students were far from comparable to the Brussels students in L2 proficiency, indicative of the significant role of the larger social context in SLA.

The sociolinguistic context also plays a role in the amount of L1 and L2 use, as FI students are usually only presented with the opportunity to practice the L2 in the school setting, whereas they use their L1 on a consistent basis in the English dominant community. Furthermore, L2 use does not necessarily equate to L2 exposure; even though these children are exposed to French on a regular basis for approximately 6-7 hours a day, much of their day comprises of listening to the L2 (e.g. Swain, 1985). With much emphasis being placed on listening, students are provided with fewer occasions to practice the L2. It should be stressed that L2 output is equally necessary in the scope of SLA in order to bolster proficient L2 expressive abilities. As pointed out by Genesee (1978), children show a strong ability in decoding language and much less so in generating it. This may be partly attributed to the uneven balance between input and output.

A problem that does arise in FI classrooms, however, is that even though the immersion program strongly encourages students to speak French in the classroom, when students are given the opportunity to practice their L2 output through participation in group activities with classmates, as noted by Swain and as experienced first-hand by the author of this thesis, students often revert back to their L1. Evidently, a lack of L2 practice will in turn influence production abilities in SLA. Cummins (1998) suggests that even though teachers report L1 use among FI students in group activities, one possible approach is to continue encouraging group work, even if the L1 is used at times, but to entail the finished product to be in French (e.g. presentation, final written report). I propose that another option is to encourage class discussions while giving students the opportunity to take the lead in the classroom with the instructor providing feedback while supervising L2 use, thus generating a student-centred environment.

4.5 Implications

The present research fosters theoretical implications by broadening our understanding of early L2 phonetic acquisition in the immersion classroom. More precisely, the findings highlight how VOT acquisition unfolds specific to the unique setting offered by a FI program, which to date, has remained uncharted. This new found knowledge can thus be added to the existing body of research to further expand our understanding of SLA. The objective evaluation of FI students' VOT realizations allowed for a comparison between voicing categories. The observation that voicing categories are behaving somewhat differently between voiced and voiceless stops is noteworthy because it indicates that not all speech sounds are acquired similarly, with some posing greater difficulty for L2 learners, and in the case of FI students—that of the lead voicing category presenting the greatest difficulty. This finding is in accordance with previous studies and supports the claim that lead voicing may be both inherently more difficult to learn in addition to the possibility that its lacks perceptual saliency. Furthermore, through the investigation of the L2 developmental trajectory of VOT acquisition in elementary school children enrolled in an early total French immersion program, it was possible to examine the effectiveness of FI schooling in shaping language appropriate phonetic features in immersion students. The results of this thesis suggest that FI students do not achieve authentic French VOT realizations. This finding is not surprising given the factors mentioned in section 4.4 in addition to the findings reported in the previous literature. For instance, Swain (1985) brings to light that the discrepancy between FI students and Francophone children in generating French can be partly attributed to the limited opportunity FI children have to practice their L2. Cummins (1998) raises the issue in relation to the minimal native French input that the FI students receive *and* the lack of sufficient opportunity for French output bringing to the surface the particularity surrounding the FI curriculum—classrooms tend to be “transmission oriented”. As discussed in section1.2.3, it has been reported that much of the interaction in the classroom is teacher-centred (Harley et al., 1991; Wilson & Connock, 1982).

According to The handbook for French Immersion Administrators, “a successful French immersion program reflects current research and best practices from its entry point through grade 12” (Alberta Education, 2010). The results of this research can provide professionals in the educational sphere with practical information in regard to speech sound acquisition in this unique setting of L2 learning. Our findings can prove valuable in contributing to L2 teaching and may further pave the way in devising changes to the curriculum that might consider placing further emphasis on output opportunity, while placing particular stress on the acquisition of voiced stops. Class discussions and presentations will provide useful in L2 practice, conducive to more authentic pronunciation.

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Appendix A

Detailed Questionnaire Filled out by Parents for FI Students

University of Lethbridge

Department of Psychology
4401 University Drive
Lethbridge, Alberta, Canada
T1K 3M4

Please fill out this brief questionnaire on behalf of your child and hand it in along with the consent form.

Child's name: ____________________ Gender: ___ Date of Birth: ___________ Age: ___ Grade: ___

Classroom teacher:______________________

Your name: ______________________

Telephone: ___________________ E-mail: _______________________

Where was your child born? __________________

What is your child's native language? ___French ___English ___Other, please specify: _________

At what age did your child learn English? _____________

At what age did your child learn French? ____________

Does your child speak any other languages besides English and French? Y N

If yes, please specify ____________________________ Since what age? ______

Are any of your child's family members native speakers of French? Y N

If yes, who are they? _____________________

How many hours a day does your child speak French at home?

☐ 0 hrs ☐ 1-2 hrs ☐ 3-4 hrs ☐ 5-6 hrs ☐ 7-8 hrs ☐ 9-10 hrs

How many hours a day does your child speak English at home?

☐ 0 hrs ☐ 1-2 hrs ☐ 3-4 hrs ☐ 5-6 hrs ☐ 7-8 hrs ☐ 9-10 hrs

How long has your child lived in Lethbridge? _______________

Where has your child lived besides Lethbridge?
____

At what age(s) and for how long?
____

Has your child ever lived in or visited a French region? ____________

If yes, where, at what age, and for how long?
____

What is your child's ethnicity? _____________

Does your child have frequent ear infections? Y ___ N ___

Does your child have PE tubes in one or both ears in order to prevent ear infection? Y ___ N ___

Has your child participated in speech or language therapy programs in the past? Y ___ N ___

If yes, please describe ____

If yes, what age did they begin therapy? __________ What age did they complete therapy? __________

Would you like to be put in our mailing list for future studies? Y ____ N ____

Thank you for participating in this study!
Dr. Fangfang Li, PhD & Dr. Nicole Rosen
Department of Psychology
Department of Modern Languages

Appendix B

Detailed Questionnaire Filled out by Parents for Monolingual English Children

Department of Psychology
4401 University Drive
Lethbridge, Alberta, Canada
T1K 3M4

Please fill out this brief questionnaire on behalf of your child and hand it in along with the consent form.

Child name: ____________________ Gender: _____ Date of Birth: ___________
Grade: ______

Your name: _______________________

Telephone: _________ Email: _______________________

Where was your child born? _______________

What is your child's primary language? ____________

Does your child speak any languages other than English? Y ____ N ____

If yes, please specify _____________

Are any of your child's family members native speakers of languages other than English?
Y ___ N ___

If yes, who are they and what language do they speak? ______________-
____

How long has your child lived in Lethbridge? _______________

How many siblings does your child have? ________________

What are the genders and ages of your child's sibling(s)?
____

What is your child's ethnicity? _____________

If your child is female, has she begun her menstrual cycle? Y____ N____

If yes, at approximately what age did it begin? __________

If your child is male, has he undergone voice change yet? (ie. puberty voice change)
Y____ N____

If yes, at approximately what age did this occur? __________

Does your child have frequent ear infections? Y ___ N ___

Does your child have PE tubes in one or both ears in order to prevent ear infection? Y ___ N ___

Has your child ever been diagnosed with a hearing, speech, or language problem? Y ___ N ___

If yes, please describe _______________________________________

Has your child ever participated in speech or language therapy programs? Y ___ N ___

If yes, please describe ____

If yes, what age did they begin therapy? _________ What age did they complete therapy? _________

Has your child ever been diagnosed with a behavioral, learning or developmental problem? Y ___ N___

If yes, please describe _______________________________________

Has your child been diagnosed with Gender Identity Disorder? Y ____ N ____

Where did you hear about this study?
____

Would you like to be put in our mailing list for future studies? Y ____ N ____

Thank you for participating in this study!

Dr. Fangfang Li, PhD, Dr. Drew Rendall, PhD& Dr. Paul Vasey PhD
Department of Psychology
University of Lethbridge

Appendix C

Word-Repetition Task Stimuli: English and French initial stop targets /p, b, t, d, k, g/

French

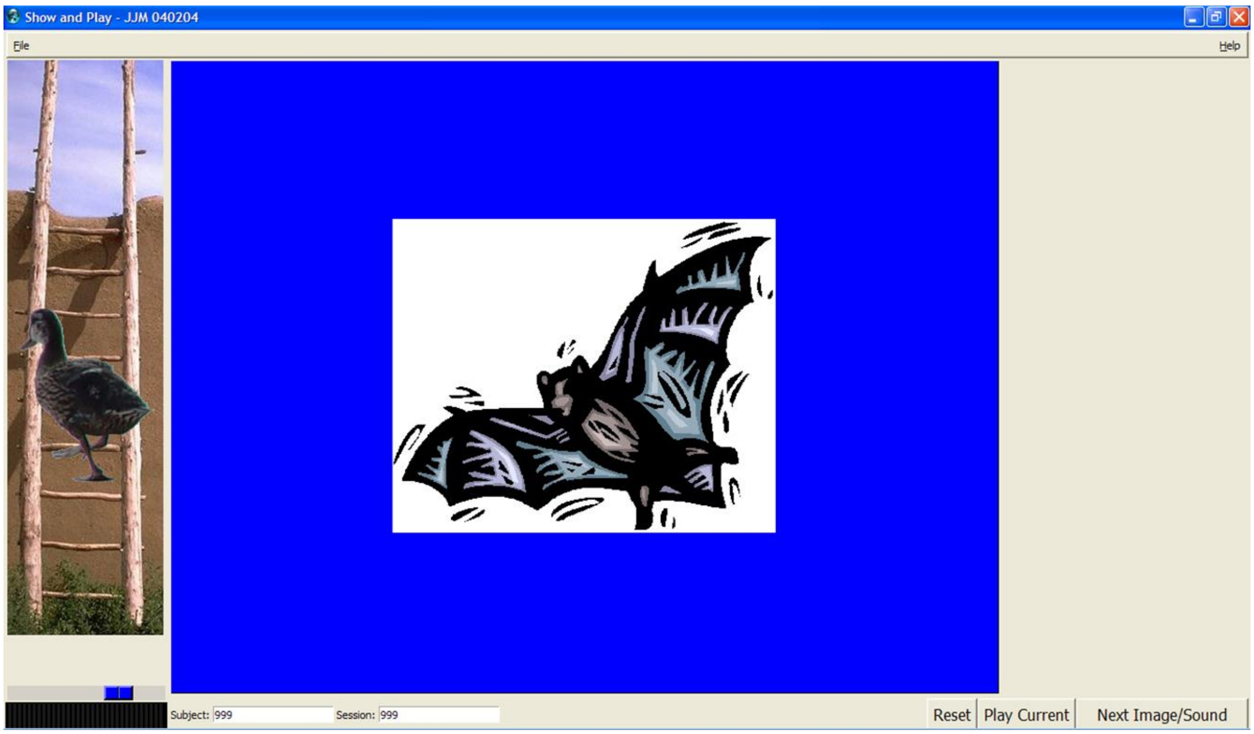
targetC	targetV			
t	i	tissu	timide	tipi
	a	table	tableau	tapis
	u	toucher	tousser	toupie
d	i	dîner	dimanche	dinosaure
	a	dame	date	dalmatien
	u	douze	doux	douleur
b	i	bicyclette	bijoux	biscuit
	a	banane	baleine	ballon
	u	bouton	bouteille	bougie
p	i	pyjama	piger	pilote
	a	papillon	papier	panier
	u	pousser	poubelle	poupée
k	i	kiwi	quitter	kilomètre
	a	cadeau	cage	camion
	u	cou	couleur	coucher
g	i	guimauve	guitare	guillemets
	a	garage	galaxie	gaspillage
	u	goût	gouvernement	gouda

English

targetC	targetV			
t	i	teeth	tea	tear
	ae	tatoo	tadpole	tap
	u	two	tools	toothpaste
d	i	deer	deal	deep
	ae	dad	dam	daffodil
	u	doodle	dude	duke
b	i	beetle	bee	beer
	ae	bat	battle	back
	u	boot	boomerang	boombox
p	i	peacock	peak	peel
	ae	paddle	panda	pacman
	u	pool	poodle	pooh
k	i	key	keyboard	kiwi
	ae	cat	can	castle
	u	cougar	cooler	cuckoo
g	i	geese	geek	gear
	ae	gas	gallop	galaxy
	u	goose	goo	goofy

Appendix D

Word-Repetition Task Visual Paradigm


Show and Play - JJM 040204
File
Help
Subject: 999
Session: 999
Reset
Play Current
Next Image/Sound

Appendix E

6-Choice Identification Task Visual Paradigm