

**Voice Onset Time in Spanish-English Bilinguals**

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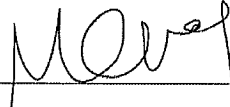
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**Abstract**

Language transfer is a linguistic process that occurs when a person's first language influences the production of their second language. Language transfer can have phonological, syntactic, and lexical properties. Phonological language transfer is often recognized as the presence of a foreign accent. Voice onset time is often used as an indicator of phonological language interference, and it can be used to understand the factors that influence accented versus accentless speech in one's second language. This article is an examination of the literature about voice-onset time in bilinguals, primarily focusing on Spanish-English bilinguals. Several different frameworks of language interference have been proposed to explain second language acquisition, including the Critical Period Hypothesis and the Speech Learning Model. These frameworks can be applied to research on second language acquisition to understand the effects of one's first language (L1) on their second language (L2). Consideration of the available literature indicates that VOT values for bilinguals depend largely on age of acquisition, code-switching, and the development of phonetic categories for different sounds. Research indicates that phonological language interference is unidirectional in the direction of the L2, and even L2 dominant bilinguals will show evidence of L1 interference when examining VOT. Further research is needed to examine the possibility of unidirectional L2 to L1 interference.

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### Introduction

The subject of language interference is a well studied area of linguistics and refers to the transfer of phonological, grammatical, lexical, and orthographical elements of one language into the learning of another (Skiba, 1997). Phonological markers of language interference can often lead to accented and non-native like speech. When specifically examining the common phonological markers of language transfer, voice onset time (VOT) is a useful feature to consider. VOT “can be defined as the time in milliseconds between the consonantal release and onset of the following vowel, or between the onset of voicing and consonantal release” (Fish et al., 2017, p. 20). VOT differs depending on both the language and the specific consonant, and it is, therefore, a valuable marker of language interference.

VOT is characterized by both duration and aspiration, the amount of air produced with the sound, and the same phoneme can be represented by different VOTs in different languages. Fish et al. (2017) explain that VOT has a positive value when phonation follows the release and has a negative value when phonation precedes the release. In the case of Spanish and English, the VOT for the voiced and voiceless occlusive consonants differ. In English, the voiced consonants /b,d,g/ have a short positive VOT between 25-30 ms, while the voiceless consonants /p,t,k/ have a long positive VOT of more than 30 ms. Long VOTs in English are blocked when the /p,t,k/ sounds are preceded by an /s/. The voiced consonants are then said to be unaspirated, while the unvoiced consonants are said to aspirated, being thus accompanied by a short puff of air. In

Spanish, the voiced consonants /b,d,g/ are produced with a negative VOT of 50 ms. The voiceless consonants /p,t,k/ have a short positive VOT of 0-25ms. The Spanish /p,t,k/ sounds are most similar to the English /b,d,g/ sounds, while the Spanish /b,d,g/ sounds are prevoiced and produced with a negative VOT that is not produced in English. These differences can account for some of what contributes to accented speech in English by L1 Spanish speakers and accented speech in Spanish by L1 English speakers. If the language learner doesn't fully recognize or understand the phonological differences between Spanish and English, then they may use VOT values that align more with their L1 and, ultimately, produce accented and non-native like speech.

Understanding the differences in VOT between Spanish and English and how these differences are realized by bilinguals can help develop frameworks of language acquisition that accurately describe L2 pronunciation trends. These frameworks can then be used to help improve language learning in the classroom and improve the phonetic categorization ability of language learners. Furthermore, developing a more clear understanding of how bilingual speakers acquire and produce their L2 sounds can help to determine the ideal way to introduce these sounds to language learners. Finally, having a comprehensive understanding of how bilinguals at different ages recognize and process VOT in their different languages can help researchers determine the best age to introduce a new language.

For a long time, language transfer was generally regarded as unidirectional in nature. The L1 influenced the L2, but research largely did not consider the possibility of the L2 having any

impact on the L1. In the period 1979-1984 interference of the L1 on the L2 was a thoroughly studied area of linguistics, but there was no interest or discussion of L2 to L1 interference (Flege, 2005). Flege indicates that this was in part due to the assumptions that researchers held at the time, including the complete neurological separation of the different phonological systems, errors in L2 that are likely due to inexperience (which is not often possible in someone's L1), and the permanence of one's L1. As will be discussed, some literature does suggest that second language dominant bilinguals can have their second language influence their first. There is also literature that suggests that code-switching may have a direct effect on VOT. This paper aims to examine the literature surrounding voice onset time in Spanish-English bilinguals and how it can be affected by different variables, including age of acquisition, code-switching, and phonetic category realization.

### **Literature Review**

#### **Types of L1 and L2 Interaction**

There are several different possible outcomes with L1 and L2 interaction. Antoniou et al. (2011) suggested four possible outcomes including 1. unidirectional L1 influence on the L2, 2. bidirectional L1-L2 interaction, 3. unidirectional L2 influence on the L1, and 4. no L1-L2 interaction. As mentioned early, unidirectional L1 influence on the L2 is one of the most studied and documented types of language interference. Bidirectional L1-L2 interference is less documented, although it is backed up by Flege (1988), who found that Spanish bilinguals had VOT that fell into three distinct ranges that were typical of both Spanish and English native

speakers. Antoniou et al. (2011) originally hypothesized that L2 dominant bilinguals would demonstrate unidirectional L2 influence on the L1. However, the results of his study did not support these claims, as the L1 Greek speakers who were dominant in their L2 of English did not demonstrate more English-like VOT when code-switching from English to Greek, while their English VOT was more Greek-like following a code switch. The final outcome of no L1-L2 interaction was not observed in any of the literature surrounding VOT in bilinguals and therefore, will not be further investigated.

### **Frameworks of Language Acquisition**

\_\_\_\_\_ Several different frameworks of language acquisition have been proposed that can be used to explain different characteristics of language interference. Of the many theories that have been proposed, three will be described here: the Critical Period Hypothesis, the Speech Learning Model, and the Perceptual Assimilation Model. The Critical Period Hypothesis is one of the most well-known theories of second language acquisition, while other frameworks such as the Speech Learning Model and Perceptual Assimilation Model have only been developed more recently. Each framework offers its own unique perspective on the process and the factors that influence language acquisition, while also having its own drawbacks and criticisms. These frameworks can then be applied to different research surrounding language interference in order to better understand different trends that can occur. I will now discuss each framework and address some of the key criticisms that have been identified.

#### ***Critical Period Hypothesis***



The Critical Period Hypothesis is one of the most well-known frameworks of second language acquisition. In 1967, Eric Lenneberg proposed that after puberty, humans have more neurological difficulty learning a language and even speaking a foreign language without an accent (Flege, 2005). Lenneberg proposed that language acquisition should occur after the age of two and before the onset of puberty, in order to best align with cognitive development. He largely developed this model using research related to deaf children, feral children, and cognitively impaired children (Vanhoove, 2013).

One of the drawbacks of the Critical Period Hypothesis is the lack of empirical evidence backing up Lenneberg's claims (Flege, 2005). Flege (2005) explains how research has shown that even pre-pubescent foreign language learners can have foreign accents in their second language, and adult learners can have no discernable foreign accent, indicating that child learners aren't necessarily better at foreign languages than adults, as Lenneberg proposed. Furthermore, Flege (1995) emphasized the long-standing belief that neurological maturation is often cited as a limiting factor in speech learning and that many researchers do not believe new forms of language can be learned successfully after a critical period. Despite this, the Critical Period Hypothesis fails to offer clear insight into how L2 learning is different from L1 acquisition or how a foreign accent is created. The Critical Period Hypothesis, while one of the most well-known frameworks of language acquisition, does not have much empirical evidence to support its claims.

### ***Speech Learning Model***

The Speech Learning Model (SLM), proposed by Flege (2005), proposes three core principles: “L2 learners can, given adequate and sufficient input, perceive the phonetic properties of L2 speech sounds accurately[. A]s in L1 development, L2 speech learning (a) takes time, and (b) is influenced importantly by the nature of input received, and in L1 development, production is guided by perceptual representations stored in long-term memory.” In other words, L2 learners can develop an accurate phonological production of their L2 if given adequate time and input, and their production is a realization of the understanding grounded in their long-term memory. Flege states that there is no critical period and that the processes and mechanisms available during L1 acquisition are available throughout one’s lifetime. He also emphasizes that the L1 and L2 phonological systems exist in a shared space and, consequently, influence each other.

In terms of criticisms, Antoniou et al. (2011) pointed out that while the SLM does account for L1 unidirectional interference toward the L2 and for bidirectional language interference, there is no explanation for how the L2 can be produced without a foreign accent. As a result, SLM fails to explain how the L2 can be produced without a foreign accent and how unidirectional interference can occur in the direction of the L1. While the SLM does explain L1 unidirectional interference in the direction of the L2 and bidirectional language interference, there is not a clear explanation for how a speaker’s L2 can affect their L1.

### *Perceptual Assimilation Model*

Best (1991) proposed the Perceptual Assimilation Model (PAM) as a framework for phonological acquisition. Best (1991) states that L2 learners will perceive non-native sounds in

relation to their similarities to their L1 sounds. If the non-native phones are very similar to their native phones, the learner will likely fail to detect a difference, and the non-native phones will be assimilated into the same phonetic category as their native sounds. In other words, a learner will use their L1 to try to interpret different sounds in their L2, and they will assimilate sounds that they perceive to be similar between their L1 and L2. Best (1991) specifies that "by adulthood, and probably much earlier, perception of speech sounds involves the recognition of linguistic structure at the level of phonemic contrasts, and unfamiliar sounds are "assimilated" to native phoneme categories on the basis of their articulatory-gestural similarities and discrepancies" (p. 21) indicating that late language learners are more likely to produce non-native like qualities in their L2 than early learners. The biggest criticism of the Perceptual Assimilation Model is that it uses articulator phonology to describe the relationship between production and perception, although it is not clear how they are linked (Antoniou et al., 2011).

Overlap has been drawn between Flege's Speech Learning Model (SLM) and Best's Perceptual Assimilation Model (PAM). While SLM is more focused on overall L2 learning, the PAM is meant to explain nonnative-like foreign language pronunciation. The PAM falls within Flege's SLM by explaining more of how a foreign accent is produced in a L2 and thus addresses the criticism that SLM fails to explain the presence of a foreign accent in an L2.

### **Factors Influencing VOT in Spanish-English Bilinguals**

\_\_\_\_\_ I now turn to identifying the factors that have been shown to influence the voice onset time in Spanish-English bilinguals. The majority of research surrounding VOT in bilinguals

focuses on one of three main factors: code-switching, age of acquisition, and phonetic category realization. These factors have all been shown to influence the VOT of bilinguals in their L2.

While there are many other factors that have been noted as having an effect of VOT in bilinguals, including gender, personal motivation, and type of language input, these factors were less commonly focused on in favor of the aforementioned. Therefore, I will now focus on reviewing the literature on the first three factors that I mentioned.

### *Code-switching*

While code-switching has been thoroughly researched, its effects on phonetic realization in speech production has not received as much attention (Antoniou et al., 2011, p. 560), and it is, therefore, important to examine its effect on VOT to better understand the language production of bilinguals. Code-switching refers to the practice of switching between languages, and it can illuminate several interesting trends in bilingual language production. In a study done with Greek-English bilinguals, Antoniou et al. (2011) found that when L1 Greek speakers code-switched from Greek, they produced their English voiced stops with a more Greek-like VOT, even though English was both their L2 and their dominant language. When asked to code switch from English, the speakers did not produce an English-like VOT, and instead, produced a VOT consistent with Greek monolinguals. Antoniou et al. (2011) originally had hypothesized that the L2 dominant bilinguals would produce unidirectional language transfer from their L2 to their L1. However, the results did not support this hypothesis, and these findings indicate that even in L2 dominant bilinguals, a speaker's L1 still interferes with L2 production, specifically in the context of code switching.

Arvaniti & Piccinini (2015) had similar results to Antoniou et al. (2011). In an experiment with early Spanish-English bilinguals with an L1 of Spanish, VOT was measured in a context of spontaneous code switching, both with and without the added cognitive distraction of a jigsaw puzzle. When the participants had a conversation without a cognitive load, code-switching resulted in shorter VOTs in both English and Spanish. While it was unsurprising that the English VOT values shortened due to Spanish influence, it was surprising that the Spanish VOT values shortened instead of lengthening to become more English like. Arvaniti & Piccinini (2015) attributed this to the participants being L1 speakers of Spanish, who were dominant in English and less secure about their Spanish than their English, and hypothesized that they may have hyper articulated features like VOT in order to appear more competent in Spanish.

When the participants had a conversation with the added cognitive load of putting together a puzzle, only the English VOT values lengthened, while the Spanish VOT values were not impacted. Arvaniti & Piccinini (2015) originally predicted that the English VOT would shorten during the activity, not lengthen. The lengthened English VOT was later attributed to a decreased speaking rate, leading to longer aspiration times, and the lack of change in the Spanish VOT was credited to the small duration time of short lag VOT which allows little room for variation. Arvaniti & Piccinini (2015), ultimately, found that L1 Spanish speakers bilingual in English tended to have unidirectional language transfer in the direction of their L2 when code-switching, with little to no effect on their L1.

### *Age of Acquisition*

The age of acquisition has been shown to have a great impact on the pronunciation ability of bilinguals in their L2. Most research indicates that, as the Critical Period Hypothesis suggests,

younger language learners are more successful than older language learners at acquiring native-like pronunciation qualities. Flege (1988) compared English monolingual VOT values to those of Spanish monolinguals and bilinguals. The monolingual Spanish speakers produced prevoiced and short-lag VOT values, while the monolingual English speakers produced short and long-lag VOT values. One of the most interesting findings from Flege (1988) was that Spanish bilinguals produced their stop consonants with VOT values that fell into all three modal VOT ranges. This finding indicates that the Spanish speakers of English had created a phonetic category for implementing the English voiceless stop consonants and had established a realization rule for producing them. Flege's (1988) research findings supported his hypothesis that developing a phonetic category for a sound will allow a speaker to reproduce it.

Flege did emphasize that one shortcoming in his research were the differences between the monolingual Spanish speaking children and adults in his research. He noted that in the imitation activities none of the Spanish speaking children were able to produce long-lag VOT values, while four of the Spanish speaking adults were able to. He noted that two of the Spanish speaking adults had some previous experience with English which may have contributed to their ability to imitate English long-lag VOT values. Flege (1988) concluded that further research would be needed to determine whether the difference was due to an age-related difference in ability to reproduce new sounds, previous phonetic experience, or both.

In later research, Flege (1991) found that some early bilinguals could differentiate between their languages phonetically. That is to say, that Spanish native speakers who were early learners of English produced the Spanish /t/ with VOT values that were not significantly different from Spanish monolinguals. Simultaneously, these same bilinguals produced an English /t/ with VOT values that were not significantly different from English monolinguals. On the

other hand, late learners were not able to fully differentiate the two languages phonetically and produced Spanish /t/ with monolingual-like values and English /t/ with shorter, non-native-like values. Flege (1991) proposed three possible explanations for the difference between early and late learner tokens. First, he suggested that early learners may have developed a more accurate understanding of the characteristics of English voiceless stops than late learners. Second, he proposed that early and late learners may have a similar perception of the English /t/, but the late learners didn't have the same motor ability to emulate their perception of the sound. Finally, he said that it is possible that both early and late learners can perceive and emulate the English /t/ sound, but late learners "may have been unable to fully utilize their sensorimotor capabilities owing to the state of development of their phonetic system when they began learning English as an L2."

Flege's (1991) findings about the differences between early and late bilingual learners' phonetic differentiation was validated in his later research. Yeni-Komshian & Flege (2000) studied the proficiency of the English and Korean pronunciation of 240 bilingual Korean native speakers who emigrated to the US between the ages of 1 and 23 to test if age of acquisition affected the pronunciation proficiency in the speakers L1 and/or L2. The results showed that age had a clear impact on pronunciation and that young L2 learners only had a mild accent in their L2, and as the age of acquisition increased, there was a reduction in pronunciation proficiency. They also observed that native-like pronunciation of the L1 was found in forty-nine percent of the bilingual students, the majority of which were late L2 learners who acquired the language between the ages of 12 and 23. Twenty-one percent of the early L2 learners who acquired the language between the ages of 1 and 11 were noted as having a pronunciation proficiency comparable to that of monolinguals. They then stated that their results were not consistent with

the Critical Period Hypothesis. Research done by Yeni-Komshian & Flege (2000) supported Flege's (1988) and (1991) findings that early language learning leads to more native-like pronunciation, and further suggests that unidirectional L1 to L2 language interference is the most common outcome of language interference.

### **Infant-directed Speech (IDS) and Infants**

Research has also been dedicated to infants and VOT. Fish et al. (2017) examined the VOT of English and Spanish stops in English monolingual and Spanish-dominant bilingual caregivers in both infant-directed speech (IDS) and adult-directed speech (ADS). Bilinguals produced English stops with Spanish and English-like qualities depending on their proficiency. Fish et al. (2017) found that one of the features of IDS is an emphasis in the distinction between voiced and voiceless stop consonants by exaggeration, since VOT values were increased in IDS in both monolingual and bilingual participants. However, the monolinguals had a VOT increase in the positive direction while the bilinguals had a VOT increase in the negative direction indicating that there was a distinction between languages. These findings are consistent with the typical VOT of English and Spanish speakers.

Aslin et al. (1981) examined the ability of infants raised in an English-speaking environment to discriminate VOT contrasts that are not typical to English. They found that there is evidence that infants from an English-speaking environment are able to discriminate VOT differences that cross both the English adult voicing boundary *and* the voiced-voiceless unaspirated boundary in other languages such as Spanish. These findings support findings from previous research that indicate that younger learners are generally the most successful in learning other languages, as the infants were able to develop phonetic categories for sounds that were not



from their native environment. Ultimately, research has shown that VOT changes in IDS and that even infants are capable of recognizing differences in VOT.

### *Phonetic Category Realization*

Understanding phonetic categories can help L2 learners to correctly identify and produce sounds in their second language. Phonetic category realization refers to a speaker's phonetic understanding and production of a sound. If a speaker accurately produces a sound in their L2, then it can be said that they have developed a phonetic category for that sound. It is important to note that there is a lot of overlap between the research discussed previously in the age of acquisition section and research into phonetic category realization. According to Flege (1988), "phonetic realization rules are needed in a model of speech production to account for talker's ability to modify articulation (e.g., when speaking louder, more rapidly, more clearly, or with greater emphasis). They are also needed to account for cross-language differences in how universal phonetic categories are realized" (p. 730). This idea can be better understood when Flege (1988) stated that L2 learners who have an L1 with short-lag VOT values for /p,t,k/ sounds have compromise VOT values in English because they do not create phonetic categories for English stop consonants. He hypothesized that L2 learners interpret tokens of /p,t,k/ in their L1 to be the same phonetic category of tokens of /ph,th,kh/ even though they can detect acoustic differences between the two stops.<sup>1</sup> The differences in production might be attributed to a lack of establishment of realization rules for producing stops in their L2. Flege (1988) later stated that individuals who learn English as their L2 as young children do establish separate phonetic categories for English /p,t,k/ indicating that bilingual children generally are more adept at learning different phonetic categories and applying them to their respective languages. These

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<sup>1</sup> This idea aligns with the Perceptual Assimilation Model proposed by Best.

claims were supported by the findings of Piccinini & Arvanti (2015), when they found that early bilinguals were able to maintain distinct phonetic categories for both their languages.

Flege (1991) expanded on these claims, emphasizing that a young native Spanish-speaker who is first exposed to English by the age of 5 or 6 years will create a separate phonetic category for English /th/ in addition to the Spanish /t/. Spanish speakers who learn English later on are not expected to add phonetic categories for similar L2 sounds such as English /th/. As the speakers get older, they are less likely to develop a unique category for the English /th/ phone and instead refer to the Spanish /t/ phone. Flege (1991) highlights that phonetic categories are needed for accurate pronunciation and correct perception of speech sounds. Ultimately, differences in VOT can be attributed to speakers lacking a phonetic category for a unique sound in their L2, and older learners are less likely to develop a phonetic category for similar L2 sounds than early learners, aligning with the Perceptual Assimilation Model.

### **Shortcomings and Gaps in the Literature**

The literature surrounding language interference largely focuses on unidirectional interference (L1 to L2 transfer); so there are many gaps in the research surrounding L2 to L1 transfer. While Antoniou et al. (2011) did examine the VOT of L2 dominant bilinguals, it was found that bilinguals who are L2 dominant will likely suppress first language interference. Yeni-Komshian & Flege (2000) examined the VOT of English and Korean bilinguals and found that the bilinguals who learned English earlier in life (between the ages of 1 and 11) were less proficient in their L1 than bilinguals who learned English later in life (between the ages of 12 and 23). These findings indicate that it is possible that early L2 learners may exhibit more language interference in the direction of their L1, but more research is needed to support this

claim. Overall, more research is needed to specifically examine the possibility of L2 to L1 unidirectional transfer.

In the research overall, there are also several common flaws in the language used by the researchers and the methods used to examine the results. Grosjean (1992) addresses several questions that arise when examining researching into language interference, and they bear reproducing here (p. 51):

1. What do we mean when we use the terms 'bilingual' and 'bilingualism'?
2. Is the bilingual person the 'sum' of two monolinguals or a specific speaker-hearer in his or her own right?
3. Can one adequately compare monolinguals and bilinguals, and if so, can one continue to do so with traditional procedures?
4. Can the linguistic tools and methods developed to study monolinguals be used without reservation to study bilinguals?

These questions address several of the shortcomings in the research surrounding language interference and can help guide future research by more clearly defining the meaning of the word bilingual in the context of the study and understanding the complexities of bilingual language. Continuing research into bilingualism without comparing bilingual speakers to monolingual speakers may illuminate more trends into bilingual language. Banov (2014) further acknowledges although one can assume that bilinguals who do not produce tokens similar to monolinguals of both languages are somehow less bilingual, this should not be the case. Many times, bilinguals are seen as inferior with their languages without any thought or concern of the bilingual's differential needs for the two languages or the different social functions of each language, and one bilingual is not the equivalent of two monolinguals. Therefore, it is important

to recognize that examining the VOT of bilinguals in relation to monolinguals may not be the best way to examine language interference.

It's also interesting to note that many of the tokens in the research that was examined were produced in an experimental setting. If the tokens were to come from a more naturalistic setting where the speakers were comfortable, it is possible that the results may change. This issue is particularly interesting when looking at the research conducted about code-switching. It is likely that these bilinguals code-switched in a different manner than they would in a naturalistic and non-experimental setting.

### **Conclusion**

Several different frameworks of language acquisition have been proposed over the years, including the Critical Period Hypothesis, the Speech Learning Model, and the Perceptual Assimilation Model. These frameworks can be used to understand the different outcomes of language interference that can occur, including unidirectional L1 to L2 interference, bidirectional L1-L2 interference, unidirectional L2 to L1 interference, and no L1-L2 interaction. Most of the literature about VOT has shown that phonological interference is largely unidirectional L1 to L2 interference. The research surrounding the VOT of bilinguals can offer insight into language interference and help shape a better understanding of how best to teach foreign language learners phonetic rules in their L2. It has largely been shown through the literature that code-switching, age of acquisition, and phonetic categorization all have an impact on a L2 learners ability to produce their L2 with more native-like VOT values. It is important to be aware that comparing bilingual speech to those of monolinguals may not be productive, and it may be better to recognize the uniqueness of bilingual speech. Moving forward, more research into the possibility

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of L2 to L1 unidirectional language transfer should be examined in order to better understand what factors can cause a bilingual's L2 to affect their L1.

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