CROSSLINGUISTIC INFLUENCE IN THE DISCRIMINATION OF KOREAN STOP CONTRAST BY HERITAGE SPEAKERS AND SECOND LANGUAGE LEARNERS

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREIVIATIONS

AOA: Age of acquisition

f0: Fundamental frequency

HL: Heritage language

HS: Heritage speaker

L1: First language

L2: Second language

SLM: Speech Learning Model

SLM-r: The Revised Speech Learning Model

VOT: Voice onset time

ABSTRACT

The current thesis investigated to which extent Korean heritage speakers (N = 20) maintain their L1 phonology by comparing their perceptual abilities with those of native speakers and English-speaking second language learners of Korean (N = 20) in an AX discrimination task. An AX discrimination task was implemented to measure perceptual accuracy of participants in discriminating the Korean lenis–aspirated stop contrast (aspirated stops: 'ㅍ' [p^h], 'ㅌ' [t^h], 'ㅋ' [k^h]; lenis stops: 'ㅂ' [p], 'ㄷ' [t], 'ㄱ' [k]) which is believed to be the most challenging among the Korean laryngeal categories to acquire not only for second language learners but also native speakers. To investigate whether linguistic factors known to be correlated with overall proficiency of heritage speakers can extend to Korean heritage speakers' perceptual abilities, the current thesis examined the effects of language use and exposure, age of acquisition, and articulation rate on the perceptual accuracy in the AX discrimination task. Results of a mixed-effects logistic regression model showed that heritage speakers were as accurate as native speakers in discriminating the contrast while outperforming second language speakers. Another finding of the current study is that verbal fluency of heritage speakers measured by articulation rate was found to be a predictor for their perceptual accuracy. The results align with previous work suggesting that heritage speakers have the advantage of early language exposure and use that is sufficient to develop and maintain native-like phonological perceptual abilities later in life.

CHAPTER 1. INTRODUCTION

1.1 Heritage Speakers

Heritage speakers (HS) refer to bilinguals who use an immigrant language at home while speaking a different language dominantly spoken in their country of residence. (Polinksy, 2011; Valdés, 2000, 2005). According to the 2018 US Census (U.S. Census Bureau, 2018), there are approximately 1.1 million Korean HSs in the US who were born in the country or moved to the US at an early age. These HSs undergo distinct language developments from both native Korean speakers in South Korea and native speakers of American English learning Korean as a second language (L2). First, their childhood language experience is different in language exposure and use from those of native speakers and L2 learners. Specifically, both native speakers and L2 learners are mainly exposed to their native language (Korean and English, respectively) during early childhood. In contrast, HSs are generally exposed to their heritage language (HL) (L1, Korean) first, but during their early childhood (as early as 2 years of age in the current study), they are also exposed to the dominant language (L2, English) (Polinsky & Kagan, 2007). Second, the majority of HSs undergo a flip in their dominant language as their HL (Korean) becomes less dominant while their L2 (English) becomes more dominant (Kondo-Brown, 2006; Polinsky, 2008; Silva-Corvalán, 1994; Valdés, 2005). For instance, most HSs living in the United States show a decrease in both exposure to and use of their HL as they reach school age. As shown in Figure 1, the use of HL (L1), shown by the ratio of HL use and the dominant language use (English), dramatically decreases from 70.2% to 18.9% from the age of 6 to the age of 12, and the ratio decreases continually until it reaches 1.3% at the age of 18 + years old (Carreira & Kagan, 2011). This decrease differentiates HSs from L2 learners who begin to use and to be exposed to L2 as they start to receive formal education while maintaining their native language (English) as the dominant language. As a result, HSs represent a unique category of bilinguals. Nevertheless, as other bilinguals, HSs can be subject to crosslinguistic interaction between the two languages they speak. Therefore, both discrepancies and similarities between HSs and L2 speakers motivate the current thesis to investigate the crosslinguistic influence in HSs relying on the existing model of L2 speech, Speech Learning Model (SLM/SLM-r Flege, 1995, 2003; Flege & Bohn, 2020).

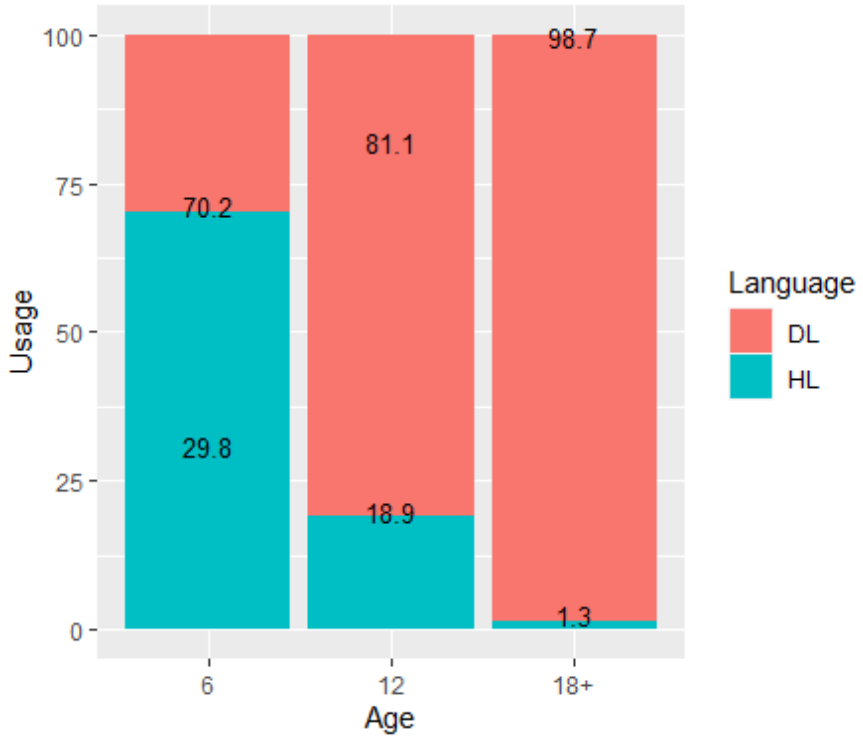

Figure 1. A change in HSs' dominant language living in the United States. DL and HL refer to dominant language and heritage language, respectively. The figure is based on the reports of the National Survey (Carreira & Kagan, 2011).

CHAPTER 2. LITERATURE REVIEW

2.1 Speech Learning Model

In terms of language acquisition, HSs show a distinctive acquisitional development in that they first acquire their HL (L1) and then acquire L2 dominantly spoken in their country of residence, but eventually, their L2 becomes more dominant later in life, especially in the US (Kondo-Brown, 2006; Polinsky, 2008; Silva-Corvalán, 1994; Valdés, 2005). In contrast, L2 learners generally acquire their first language and then learn a second language while their first language is maintained as their dominant language. Although the two types of bilinguals are distinct from each other in acquisitional development of language, they are similar as well in that their L1 and L2 influence each other in a bi-directional manner (Asherov et al., 2016; Chang et al., 2011; Chang & Mandock, 2019; Chang & Yao, 2016; Cheng, 2017; Flores & Rato, 2016; Kang et al., 2016).

The current thesis makes predictions with respect to HSs' and L2 learners' phonological perceptual discrimination based on the assumptions of Speech Learning Model (SLM/SLM-r). SLM postulates that there exists a shared space in the mental representation where sound categories of both L1 and L2 coexist and affect each other (Flege, 1995, 2003; Flege & Bohn, 2020). The model accounts for various outcomes from such crosslinguistic influence in L2 learners such as mergers (proposed as diaphones), assimilation, and dissimilation, through the mechanism of equivalence classification. The core idea of the model is that crosslinguistic influence is expected between the sound categories of the two languages. Crosslinguistic influence can be defined as phonetic changes in a sound category of one language under the effect of the category of another language. As an analogy, the two sound categories of two different languages attract each other like the North and South magnetic poles, changing in merged categories as shown in Figure 2. The model predicts that such crosslinguistic links are established when a sound category of one language is phonetically and phonologically similar, but not acoustically identical, to another sound category of the second language.

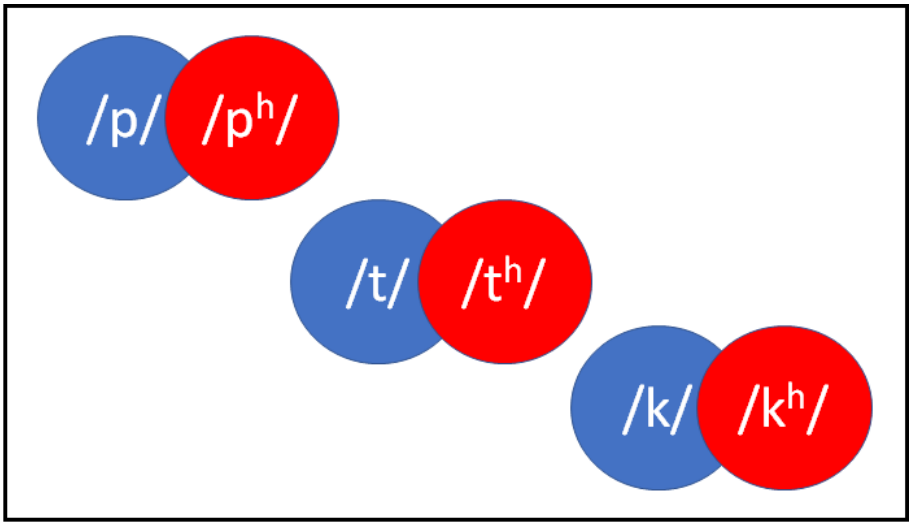

Figure 2. A virtual representation of similar sound categories in two languages influencing each other. The figure shows crosslinguistic links between English voiceless stops colored in blue and Korean aspirated stops colored in red.

Previous work has shown such crosslinguistic influence in L2 speech production (Baker & Trofimovich 2005; Bergmann et al., 2016; Caramazza et al., 1973; Chang, 2013; Dmitrieva et al., 2010; Flege, 1987; Flege & Eefting, 1987a, 1987b; Fowler et al., 2008; Guion, 2003; Harada, 2003; Lang & Davidson, 2019; Major, 1992; Peng, 1993; Sancier & Fowler, 1997). For example, Dmitrieva et al. (2010) examined whether Russian speakers residing in the US articulated Russian word-final obstruents in an English-like fashion, due to the crosslinguistic influence of English on Russian. They demonstrated that Russian native speakers with knowledge of English living in the US used an increased use of vowel duration (English-like) in addition to the phonetic cues used by monolingual Russian speakers, such as closure/frication duration and release duration. Similarly, Chang (2012) found a crosslinguistic influence of English (L1) on Korean (L2) in American L2 learners of Korean during their enrollment in an extensive Korean language class while staying in South Korea. The study supported the presence of crosslinguistic influence by demonstrating that their English vowels were drifted towards Korean vowels after immersion in the Korean language while Korean lenis and aspirated stops were merged into a voiceless stop due to the influence from the different laryngeal categories in English.

Perceptual evidence for crosslinguistic influence is less abundant than that from production studies. Nevertheless, recent work demonstrates that experience and knowledge of L2 can affect the way that L1 speech is perceived. For example, Dmitrieva (2019) showed that Russian

bilinguals who speak English as L2 behaved similarly with monolingual English speakers in perceiving Russian stop voicing. Specifically, they relied on vowel duration to a greater degree and glottal pulsing duration to a lesser degree as monolingual English speakers than monolingual Russian speakers. In contrast, monolingual Russian speakers put a greater acoustic cue weight on glottal pulsing duration than vowel duration (see also Antoniou et al., 2012; Garcia-Sierra et al., 2009; Hazan & Boulakia, 1993). The evidence of crosslinguistic influence in both production and perception in L2 speech suggests that phonetically and phonologically similar sound categories across two languages affect each other.

2.2 Korean Stop Contrasts and Their Acquisition

The Korean language exhibits a typologically rare distinction in stop consonants: lenis stops, 'ㅂ, ㄷ, ㄱ' /p, t, k/, contrast with aspirated stops, 'ㅍ, ㅌ, ㅋ' /p^h, t^h, k^h/, and fortis stops, 'ㅃ, ㄸ, ㄲ' /p*, t*, k*/. Not only voice onset time (VOT) but the onset f0 of a following vowel cues the contrast perceptually (Cho et al., 2002; Han & Weitzman, 1970; Kagaya, 1974; Kim et al., 2002; Kong et al., 2011; Lee et al., 2013; Lee et al., 2020; Lee & Jongman, 2019). As seen in Table 1, both lenis stops and aspirated stops are characterized by a long lag VOT (over 30ms), but they differ in f0 with lenis stops having lower f0 values than aspirated stops (Bang et al., 2018; Chang & Mandock, 2019; Kang, 2014; Kang & Guion, 2008; Kong & Yoon, 2002; Silva, 2006). Lenis stops and fortis stops contrast in both VOT and the onset f0 of a following vowel with fortis stops having shorter VOT and higher f0 values. Although the vocalic cue of f0 for the stop contrast was considered as a characteristic of the Seoul dialect and young speakers, recent studies discovered that the role of VOT cue in the stop contrast has weakened over the past 60 years while that of f0 has increased as a primary vocalic cue across dialects and generations (Kang, 2010; Kim et al., 2002; Kong et al., 2011; Lee et al., 2013; Lee et al., 2020; Lee & Jongman, 2019). Figure 3 shows the spectrograms of the lenis–aspirated contrast /ka/ and /k^ha/ recorded by the author of the thesis who is a native speaker of Korean from the Seoul-Gyeonggi area. While both stops have long-lag VOTs (97ms and 113ms, respectively), the lenis stop is characterized by its lower onset f0 (108 Hz) than the aspirated one (132 Hz).

Table 1. Korean stop contrast

Stop	VOT	F0
Lenis stops	Long lag	Low
Aspirated stops	Long lag	High
Fortis stops	Short lag	High

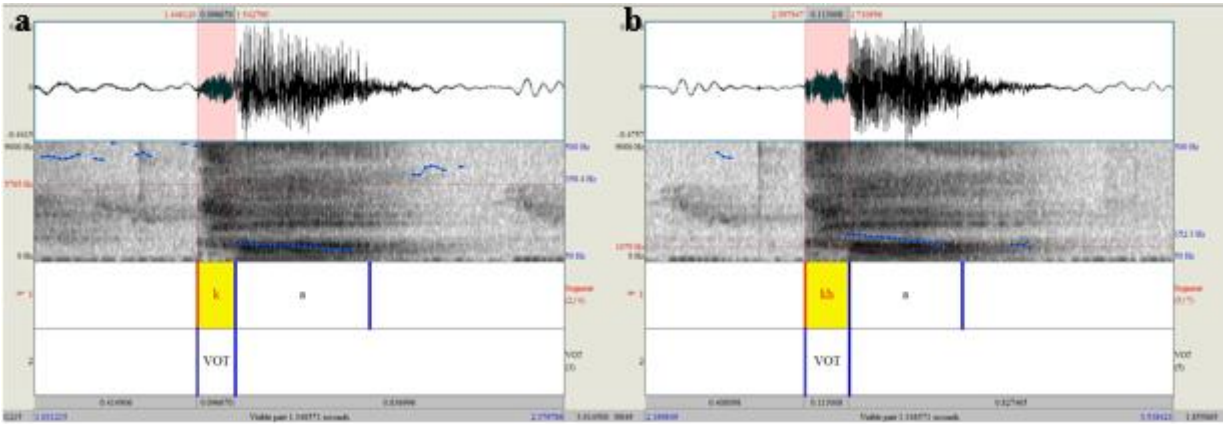

Figure 3. Spectrograms showing the lenis–aspirated stop contrast in Korean. (a) is a spectrogram of the lenis stop in /ka/, and (b) is a spectrogram of the aspirated stop in /k^ha/.

Previous work showed that this rare distinction in Korean stop consonants poses perceptual difficulties to L2 learners whose native language has a two-way stop distinction contrasted by VOT. Particularly, it has been demonstrated that the lenis–aspirated stop contrast is more challenging for L2 speakers to discriminate than the lenis–fortis and aspirated-fortis stop contrasts. For instance, several studies found that native speakers of English, Japanese, and Mandarin Chinese studying Korean as L2 tend to show a merged perception of lenis and aspirated stops of Korean as aspirated stops (Chang et al., 2011; Cheon & Lee, 2013; Holliday, 2014, 2019; Schmidt, 2007; Yasuta, 2004). The studies suggested that since the f0 cue plays a primary role in discriminating the Korean lenis–aspirated stop contrast, L2 learners whose native language does not rely on f0 to such an extent in discriminating laryngeal categories tend to merge lenis and aspirated stops into aspirated stops.

In contrast, the English language has a two-category contrast between voiced and voiceless stops as shown in Table 2. Specifically, voiceless stops have long-lag VOTs while voiced stops are characterized by shorter VOTs (Abramson & Lisker, 1985). In English, onset f0 also cues phonological voicing (Dmitrieva et al., 2015; House & Fairbanks, 1953; Lehiste & Peterson, 1961;

Ohde, 1984), but it plays decisively a secondary role in perception (Idemaru & Holt, 2011; Llanos et al., 2013; Whalen et al., 1993).

Table 2. English stop contrast

Stop	VOT	F0
Voiceless stops	Long lag	High
Voiced stops	Short lag	Low

When it comes to the acquisition of stop consonants in Korean and English, developmental evidence indicates that it takes longer for native Korean children to master their native laryngeal categories (not before the age of 4) than for native English children to acquire voicing categories (fully developed by the age of 2 or 3) (Bernthal et al., 2013; Jun, 2007; Kim & Stoel-Gammon, 2009; Lowenstein & Nittrouer, 2008). Furthermore, studies looking closely at Korean children acquiring the laryngeal categories revealed that lenis stops and their contrast with aspirated stops are the last to be mastered while fortis ones are the earliest to acquire (at the age of 17 months), (Choi et al., 2019; Jun, 2007; Kim & Stoel-Gammon, 2009). Kong et al. (2011) suggested that early acquisition of fortis stops can be attributed to VOT being the only distinctive cue to distinguish them from the other types of stops. Other studies also suggested that the challenging necessity to rely on f0 to perceive the contrast between lenis stops and fortis/aspirated stops causes a delayed acquisition both for native speakers and L2 learners (Chang & Mandock, 2019; Cheon & Lee, 2013; Ko, 2018; Oh et al., 2010). Given the challenging nature of Korean lenis–aspirated contrast, it could be more susceptible to attrition due to the influence from the dominant language in HSs. L2 learners of Korean may also experience difficulties in its acquisition due to reliance on L1, English, in approaching the production and perception of L2 laryngeal categories. Therefore, it is predicted that both HSs of Korean and L2 learners of Korean will be different from native speakers in their discrimination of the lenis–aspirated stop contrast.

2.3 Crosslinguistic Interaction between Korean and English Stops

Evidence suggests that Korean stops are sufficiently similar to the English laryngeal categories to trigger crosslinguistic interactions in Korea-English bilinguals in HSs and L2 learners (Ahn et al., 2017; Chang & Mandock, 2019; Cheon & Lee, 2013; Cheng, 2017 among others).

Crosslinguistic assimilation studies indicate that native speakers of Korean perceive English voiceless stops to be similar to Korean aspirated stops, while English voiced stops are perceived as similar to Korean lenis stops, as illustrated in Table 3 (Cheon & Lee, 2013; Schmidt, 1996). Therefore, the Korean lenis–aspirated pair can be assimilated to the English voiced-voiceless pair. Given that Korean lenis–aspirated distinction relies mostly on f0, while English voiced-voiceless distinction relies mostly on VOT, the bi-directional crosslinguistic influence between the two is observed in the relative reliance on VOT vs. onset f0 in producing and perceiving the laryngeal categories, in comparison to monolingual native speakers.

Table 3. Assimilation of English stops to Korean stops by Korean native speakers

English stops	VOT	F0	Korean stops	VOT	F0
Voiceless stops	Long lag	High	Aspirated stops	Long lag	High
Voiced stops	Short lag	Low	Lenis stops	Long lag	Low

For example, Kong and Yoon (2013) found that a decreased reliance on VOT in producing the voiced-voiceless distinction in English is a hallmark of a lower-proficiency Korean learner of English when compared to an English native speaker. Instead, Korean-English bilinguals produce a more salient distinction in terms of onset f0 between English stops, compared to English monolinguals (Kong & Yoon 2013; Kang & Guion, 2006; Kim, 1994; Kim, 2012).

On the flip side, several studies have also demonstrated the influence of English on Korean stops (Cheng, 2017; Kang & Nagy, 2016; Oh & Daland, 2011; see also Lee & Iverson, 2012; Oh, 2019; and Yoon, 2015, for evidence from bilingual children). Specifically, the studies found that Korean HSs in the US and Canada maintained a VOT-based separation between lenis–aspirated Korean stop, unlike native speakers in Korea, who merged the two in terms of VOT and maintained only an onset f0 difference.

While much evidence from production supports the crosslinguistic link between Korean and English stops, few studies have approached the link from the perceptual point of view. Kong (2012), for instance, examined Korean-English bilinguals' cue-weighting in perceiving Korean stops. The study demonstrated that while bilinguals relied more on f0, they also showed a significant reliance on VOT, possibly due to crosslinguistic influence of English stops.

Despite a little evidence from HSs' perception, the considerable evidence from production studies indicating the crosslinguistic influence of a dominant language makes it conceivable that Korean HSs in the US, as well as English-speaking L2 learners of Korean, will perceive Korean laryngeal contrasts differently from native speakers due to their English influence. Specifically, it is predicted that both HSs and L2 learners will show a great reliance on VOT (English-like) and a lesser reliance on onset f0 (Korean-like) in perceptually discriminating the Korean stop contrasts while native speakers will dominantly rely on onset f0 for the same contrasts. Since f0 is in fact the primary correlate of this contrast in production, those listeners who rely on f0 in perception are expected to have greater success in discrimination. In the remaining of the chapter, linguistic factors that have been shown to affect HSs' and L2 learners' phonology will be briefly introduced. Following linguistic factors, research questions and hypotheses of the current thesis will be formulated based on the previous literature.

2.4 Background Factors Affecting Performance of Heritage Speakers and L2 Learners

Previous work on HSs investigated whether linguistic factors documented to be associated with L2 proficiency can be used to predict the proficiency of HSs. This section introduces selected background factors that have gained the most attention in previous work on L2 acquisition as well as HL during the past decades. The background factors discussed in the current section were used in the analysis of the current study to examine the effect of each variable on the perceptual accuracy of HSs and L2 speakers.

2.4.1 Proficiency

Previous work showed that HL proficiency is predictive of speakers' performance in phonetics and phonology as well as morphosyntax, such that HSs with high proficiency in their HL are characterized with more native-like performance than those with low proficiency (Nagy & Brook, 2020; Polinsky, 2008; Polinsky & Kagan, 2007). Proficiency can be evaluated in a variety of ways, for example, by using self-reported scores on Likert-scales or by administrating standardized proficiency tests, or tests that measure a certain aspect of linguistic proficiency but strongly correlate with overall proficiency, eg. cloze test (Bormuth, 1968) or LexTALE test (Lemhöfer & Broersma, 2012). One approach which has been gaining popularity relies in measuring verbal fluency as an estimate of overall proficiency. For instance, Polinsky and Kagan

(2007) and Polinsky (2008) demonstrated that speech rate was positively associated with Russian HSs' performance in Russian gender-matching tasks. More recently, Nagy and Brook (2020) echoed and confirmed Polinsky's study (2008), indicating that HSs articulation rate, as well as speech rate, was positively correlated with native-like production of stop consonants in both Italian and Russian. That is, HSs with faster speech in their HLs patterned more similarly to native speakers than those with slower speech. Based on the evidence, the current thesis uses verbal fluency as an estimate of overall proficiency of both HSs and L2 learners.

2.4.2 Age of Acquisition

Bilingual speakers are often categorized by the age of acquisition (AOA) of their L2 such as simultaneous bilinguals who started to acquire both L1 and L2 from birth, early bilinguals who started to acquire L2 during early childhood, or late bilinguals who started to acquire L2 after a biologically determined period, puberty. This distinction is motivated by the evidence that early bilinguals tend to perform closer to a native-like level than late bilinguals (Flege, 1987, 1992, 1995). In addition to the behavioral evidence, evidence from cognitive science indicates that AOA plays a significant role in processing L2. For instance, Kim et al. (1997) and Perani et al. (1998) measured neural activities in the brains of early and late bilinguals using the functional magnetic resonance imaging (fMRI) method. They discovered that when processing L2, not only the activated cortex areas were different between early and late bilinguals, but late bilinguals showed greater neural activation than early bilinguals. This suggests that the increased cognitive load in late L2 speakers in the brain can negatively affect their L2 performance. In contrast, the study suggested that early bilinguals with less or little cognitive load in processing L2 are expected to perform closer to a native-like level than late L2 learners. Based on the evidence, it is predicted that HSs, who typically start to acquire their HL from birth, will perform closer to native speakers than late L2 learners. For this reason, AOA (English for HSs and Korean for L2 learners) is also tested in the present study as a possible predictor of perceptual accuracy among HSs and L2 learners.

2.4.3 Language Use and Exposure

Researchers agree that HSs' childhood use of and exposure to HL provide advantages for both speech production and perception. For instance, several studies that compared the production of heritage and L2 speakers of Spanish and Korean found that the production of HSs was similar to that of native speakers while outperforming even advanced L2 speakers (Chang & Mandock, 2019; Knightly et al., 2003; Oh et al., 2003; Oh et al., 2010). At the same time, the literature suggests that while HSs have advantages over late L2 learners, their use of acoustic cues may nevertheless be different from native speakers due to decreased use of and exposure to their HL (Asherov et al., 2016; Chang et al., 2011; Chang & Mandock, 2019; Chang & Yao, 2016; Cheng, 2017; Flores & Rato, 2016; Kang et al., 2016). Chang and Mandock (2019), for example, found that Korean HSs who were English dominant showed a distinct use of acoustic cues in producing Korean laryngeal stop contrasts. Specifically, while they signaled the contrasts using both VOT and onset f0 as native speakers, their VOT and f0 were significantly greater than those of native speakers. In contrast, English-speaking L2 learners relied mainly on VOT due to the crosslinguistic influence of English. The present work estimates the use of and exposure to the Korean language, using a metric of self-reported percentages from the Language Experience and Proficiency Questionnaire (LEAP-Q, Marian et al., 2007), and tests them among other possible predictors of discrimination accuracy.

2.5 Research Questions and Hypotheses

The current study focuses on the perception of word-initial lenis–aspirated stop distinction in Korean by measuring the perceptual accuracy of HSs born and raised in the US, native speakers of American English learning Korean as L2, and native speakers of Korean in South Korea. Their perceptual accuracy in discriminating the lenis–aspirated stop contrast was measured using an AX discrimination task in which they listened to pairs of monosyllabic CV-structured Korean words differing only in the word-initial stop and judged whether they were the same or different. The first goal of this study is to examine to what extent crosslinguistic influence from English to Korean laryngeal stop categories affects the phonological discrimination of the Korean lenis and aspirated stop contrast by HSs and L2 learners. The second goal of the study is to determine what linguistic

variables predict HSs' and L2 learners' perceptual competence. To achieve these goals, the current thesis pursues the following research questions and hypotheses.

2.5.1 Research Questions

1. Will HSs behave differently from L2 learners and native speakers in discriminating the Korean lenis–aspirated stop contrast?
2. Will HSs outperform L2 learners in an AX discrimination task?
3. What linguistic variables can predict HSs and L2 learners' perceptual accuracy in discriminating the stop contrast?

2.5.2 Hypotheses

1. HSs and L2 learners will show a decrease in perceptual accuracy of discriminating the Korean lenis–aspirated stop contrast compared to the native baseline due to crosslinguistic influence from their dominant language, English on Korean stop laryngeal categories.
2. HSs will outperform L2 learners in discriminating the Korean lenis–aspirated stop contrast in the AX task due to the advantage of early use of and exposure to Korean.
3. Linguistic factors including proficiency, AOA of Korean for L2 learners and English for HSs, and language use and exposure will be associated with HSs' and L2 learners' perceptual accuracy.

CHAPTER 3. METHODOLOGY

This chapter elaborates on the experimental designs and methods used in the current study.

3.1 Participants

A group of Korean HSs, a group of L2 learners (L1: English), and one baseline group of native speakers participated in this study. All participants completed a consent form and filled in a modified version of LEAP-Q (Marian et al., 2007) and an adapted and translated version of Adult Language Questionnaire (ALQ, Cuza & Frank, 2014). No participant reported any disability or difficulty in speaking, hearing, and vision. The following section reports details about the language backgrounds of each group.

3.1.1 Heritage Speaker Group

The HS group consisted of 20 HSs born and raised in the US whose parents were native speakers of Korean and first-generation immigrants. They were recruited online on Prolific, an online participant recruitment platform for social science research and using a snowball technique. Participants recruited on Prolific were compensated at a rate of 6.25 USD per hour, and the others were offered a 5 USD-value Amazon e-gift card. The group consisted of 11 females and 9 males, age ranging between 19 and 42 years old (M = 25.5, SD = 5.9). According to the questionnaires, the majority (n = 14) reported that they had never resided in Korea, although five of them reported staying in Korea for between 1 and 3 years, and one lived in Korea for 10 years. Participants reported being exposed to Korean about 39% of the time on average as opposed to English (61%) at the time of the experiment while showing individual variation, ranging from 10% to 100% (M = 38.95%, SD = 20.41). When choosing to speak a language between Korean and English, when the two languages were available options, participants chose to speak Korean only 30% of the time on average although there was also a great variation, ranging from 0% to 100% (M = 30.35, SD = 27.91). They attributed their Korean competence to interactions with family members, watching TV, and reading in Korean. For AOA of English, they reported the age of 2 on average ranging from 1 to 5 (M = 2.1, SD = 1.6). For self-reported speaking and comprehension proficiency measured on a Likert-scale of 7 (1: very poor – 7: native-like), they reported that they were more

proficient in English than in Korean in both domains. For Korean speaking and comprehension proficiency, their averages were 4.7 and 5.1, respectively. In contrast, the average scores of their English speaking and comprehension proficiency were 6.8 and 6.7, respectively. In addition to self-reported proficiency, the current thesis employed a more objective measure of Korean proficiency by calculating articulation rate, verbal fluency, in a narrative task. Their average articulation rate was 4.2 syllables per second.

3.1.2 L2 Group

The L2 group consisted of 20 native speakers of American English learning Korean as L2 (14 females and 6 males), and their age ranged from 18 to 42 years old (M = 26.3, SD = 7.2). They were also recruited either on Prolific or using a snowball technique. Like the HS group, they were either compensated at a rate of 6.25 USD per hour or offered a 5 USD-value Amazon e-gift card for participation. All but three of the participants had not stayed in Korea, and the duration of stay for the three participants was from 1 to 2 years. Their reports on AOA of Korean (M = 22.3, SD = 9.5) and the first quartile of AOA, that is, the earliest 25% of the participants' AOA, (Q1 = 20.75) qualified them as late bilinguals. These participants reported considerably more exposure to English (83%) than to Korean (17%) (SD = 13.0) on average. When they could choose to speak a language between English and Korean, they also reported a strong preference for English (83%) over Korean (17%), on average. Their average self-reported Korean proficiency in speaking and comprehension was 2.7 and 3, respectively (on a 7-point scale). In contrast, the averages of their self-reported English-speaking and comprehension were 7 on both domains. Their average articulation rate in the narrative task was 3.4 syllables per second. Table 4 summarizes the reports on the language backgrounds of the participants in L2 and HS groups.

Table 4. Language backgrounds of HSs and L2 speakers

Question	HS	L2
Age	25.5 (5.9)	26.3 (7.2)
AOA (HS: English, L2: Korean)	2.1 (1.6)	22.3 (9.5)
Current exposure to Korean [a]	39% (20.4%)	17% (13%)
Percentage of choosing to speak Korean over English [b]	30.4% (27.9%)	17.1% (19.2%)
Korean speaking proficiency [c]	4.7 (1.6)	2.7 (1.8)
Korean comprehension	5.1 (1.3)	3 (1.8)
English speaking proficiency	6.8 (0.7)	7 (0)
English comprehension	6.7 (1.3)	7 (0)

a: a 100% scale is used for exposure (0%: English only – 100%: Korean only)
b: a 100% scale is used for preferred language (0%: English only – 100%: Korean only)
c: Speaking and comprehension proficiency in both languages are represented on a 7-point Likert-scale (1: very poor – 7: native-like)

3.1.3 Baseline Group

The baseline group consisted of 20 native speakers born and raised in South Korea (14 females and 6 males). Their age ranged between 20 and 34 years old (M = 24.2, SD = 3.3), and they were either college students or alumni of a university located in Seoul. At the time of the experiment, they were residing in the Seoul-Gyeonggi area in South Korea in which the same variety is spoken. As English education is ubiquitous in South Korea, all participants had some knowledge of English (Park, 2009 among others). This was indicated by their AOA report that they started to learn English at the age of 7.5 on average. However, as English education in Korea mainly focuses on grammar and reading, their English experience is different in quality from that of HSs in the current study who were born and raised in the US. These participants were compensated with a 5 USD-value Starbucks e-gift card for participation.

3.2 Materials

3.2.1 Stimuli for the AX Discrimination Task

In the AX discrimination task, participants listened to pairs of Korean words and judged whether they were the same or different. The current study adapted 72 monosyllabic Korean words from stimuli used in Schmidt (2007). Four female native speakers, three of whom were from Seoul, and the other from the Chung Cheong area, recorded the stimuli. These speakers had been in the

US for no more than three years and reported to be exposed to English 30% or less on average during their stay in the US. More details about the stimuli are elaborated on in Schmidt (2007). From the original set of stimuli which consisted of 684 CV words, 72 were selected. These words all began with either a lenis stop or an aspirated stop, contrasting in three different places of articulation (/p/, /t/, /k/) and three different vowels (/a/, /i/, /ɯ/), resulting in a total of 18 unique CV words (2 types of stops (lenis, aspirated) * 3 places of articulation (/p/, /t/, /k/) * 3 types of vowels (/a/, /i/, /ɯ/) * 4 different speakers).

To ensure the audio quality of the stimuli, the author of the current thesis, a native speaker of Korean, checked and selected the stimuli from the original set of stimuli. In addition, the current study performed acoustic analysis with a visual inspection of the spectrograms of the 72 stimuli of lenis and aspirated stops consisting of an equal amount from each speaker, using Praat 6.1.10 (Boersma & Weenink, 2021) to ensure that the two types of stops are contrasted by *f*0 while having overlapping long-lag VOT values. The results showed that the contrast between the two kinds of stops was attributed to both *f*0 ($t = 10.65$, $p < .001$) and VOT ($t = 5.62$, $p < .001$) although there was a considerable overlapping between the lenis and aspirated ranges. Figure 4 shows the difference in the VOT and f0 values between lenis and aspirated stops in the stimulus set. As seen in the figure, the lenis stops exhibit a greater variability in VOT values than in f0 values, resulting in a greater overlapping in VOT than in f0 with aspirated stops. This analysis suggests that the vocalic cue of onset f0 is important to the discrimination of the lenis–aspirated contrast in Korean because VOT on its own may be an unreliable cue to this distinction.

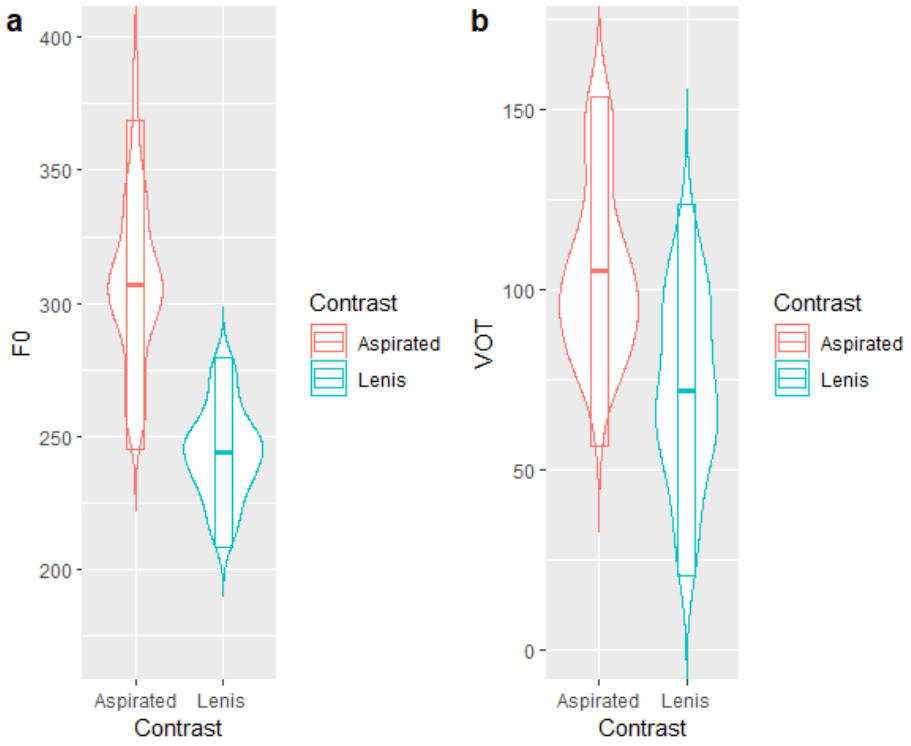

Figure 4. Violin plots of the lenis–aspirated stop contrast in the stimuli. (a) shows the comparison of f0, and (b) shows the comparison of VOT.

3.2.2 Picture Description Narrative Task

For the picture description narrative task, a series of pictures of *Little Red Riding Hood* were used to elicit narrative production. The narrative task has been used to examine proficiency in grammar (Cuza, 2008; Rojas & Iglesias, 2013; Sebastian & Slobin, 1994). In the current study, the production was used to measure verbal fluency to estimate participants speaking proficiency in Korean. The book consisted of a total of 9 pictures, and the name of the main character was provided in Korean as "ppalgan tugeon sonyeo (*빨간 두건 소녀*, 'red riding hood girl')". This task took approximately five minutes to complete.

3.3 Procedures

3.3.1 AX Discrimination Task

The current study was implemented using a Gorilla interface (Anwyl-Irvine et al., 2019) which is an online research platform for behavioral science. Before performing the task, all

participants were asked to wear either headphones or earbuds to minimize environmental noise. The use of sound equipment was checked by a headphone check function in Gorilla in which triplets of beep-like noise differing in amplitude were played. After listening to each triplet, they were asked to decide the order of the sounds by loudness. Only those whose accuracy was over 80% could proceed to the next stage while those who did not pass the check were given another trial. If they could not pass the check twice, then their session was coded to be closed. However, no participant failed the headphone test twice. Those who passed the headset check were given an instruction on how to perform the AX task and a practice of five trials before performing the actual task. In this task, participants listened to pairs of Korean monosyllabic words that only differed in the word-initial stop (lenis/aspirated), and they judged whether two words were the same or different. When the task started, Word A and X were played with an interval of 200ms between the words. This interval was set to ensure the minimum time required to recognize and process a sound signal as well as to prevent mutual masking between two words (Gerrits & Schouten, 2004 among others). Each trial screen showed two buttons by which participants registered their decision by clicking on a button. The two buttons were colored in red and blue, respectively: a red button which signaled 'different' and a blue button which signaled 'the same.' When a response was registered, a period of 500ms of a blank screen appeared before moving to the next trial. The stimuli used in this task were the same for all groups and played in a random order. With an equal number of different and same pairs (same: AA/XX, different: AX/XA) used, the total number of trials resulted in 288 for each participant ((3 types of stops (/p/, /t/, /k/) * 3 types of vowels (/a/, /i/, /ɯ/) * 2 orders (AX and XA) * 2 repetitions * 4 different speakers) + an equal number of same pairs).

In order to make the simple nature of an AX task more challenging, the current study used two different recordings for the 'same' pair stimuli. That is, the As and Xs in the same pair stimuli did begin with the same stop, but they were acoustically different because they were two different recordings by the same speaker. This apparatus prevented participants from equating same pair stimuli by relying solely on acoustic traces in which case their decision does not represent their phonology. At the same time, the phonologically same but phonetically different stimuli forced them to make perceptual judgment by assimilating the sound categories in the stimuli to those similar in their phonological inventory because they were not acoustically identical. The AX task took approximately 12 minutes for participants to complete.

3.3.2 Picture Description Narrative Task

The purpose of the picture description narrative task was to elicit narrative production data. The data enabled the study to measure their verbal fluency by calculating articulation rate, which was used as an estimate of proficiency. Following the AX discrimination task, participants were provided with an optional five-minute break before performing the task. Participants were given a written instruction on the screen and requested to complete the task in a quiet place. When the task began, participants were shown a series of wordless pictures of *Little Red Riding Hood*. They were asked to describe the pictures in Korean using their own microphone. Their production was recorded using the recording function in Gorilla and saved as MP3 files, and participants could use any recording device of their preference for this task. The productions elicited from the narrative task were analyzed acoustically to measure the articulation rate of each participant. The articulation rate was calculated by dividing the number of syllables in the narrative (estimated as the number of vocalic nuclei) by the duration of the narrative (without pauses) to obtain the number of syllables per second (see Baker-Smemoe et al., 2014; De Jong, 2018; Ginther et al., 2010; Kormos & Denes, 2004; Nagy & Brook, 2020 for more discussion). Each recording was analyzed by deploying a script by De Jong and Wempe (2009) in Praat 6.1.10 which has been widely used in measuring verbal fluency.

3.4 Analysis

The registered answers (blue button or red button) from the AX judgment task were categorized as correct or incorrect.

All statistical analyses in this study were conducted using RStudio 1.4.1103 (RStudio Team, 2020), and all mixed-effects models were implemented using the 'lme4' package (Bates et al., 2015). The current study implemented three mixed-effects logistic regression models in which the dependent variable was participants' perceptual accuracy coded binarily as either '1' (correct answer) or '0' (incorrect answer).

The first model was designed to analyze the effect of participant group on discrimination performance. For this purpose, the model included group (HS, L2, Native), trial type (same- or different-pair trials), their interaction, and speaker (the four female speakers who recorded the stimuli) as fixed factors. It also included item and subject as random intercepts.

The second and the third models were implemented to analyze the effect of participants' language background factors on HSs and L2 learners' perceptual accuracy, respectively, in the discrimination task. For this purpose, the models included the following linguistic factors as fixed effects: Korean use, Korean exposure, AOA of English for HSs, AOA of Korean for L2 learners, and individual articulation rate. Due to the low quality of recorded audio files and other technical issues, 6 participants were excluded from this analysis, resulting in 18 HSs in the second model and 16 L2 learners in the third model.

CHAPTER 4. RESULTS

4.1 Model 1: Effects of Group, Speaker, and Type on Perceptual Accuracy

4.1.1 Group Effect

The results of the mixed-effects logistic regression model showed that the HS group was not significantly different from the baseline group (p = .24). However, the HS group was significantly different from the L2 group by being 86% more likely to provide an accurate judgment in discriminating the Korean stop contrast in the AX task than the L2 group (β = -2.01, SE = .16, z = -12.33, p < .001), adjusted for trial type and speaker. Figure 5 indicates that the HS group was as accurate as the baseline group in the AX discrimination task and significantly more accurate than the L2 group.

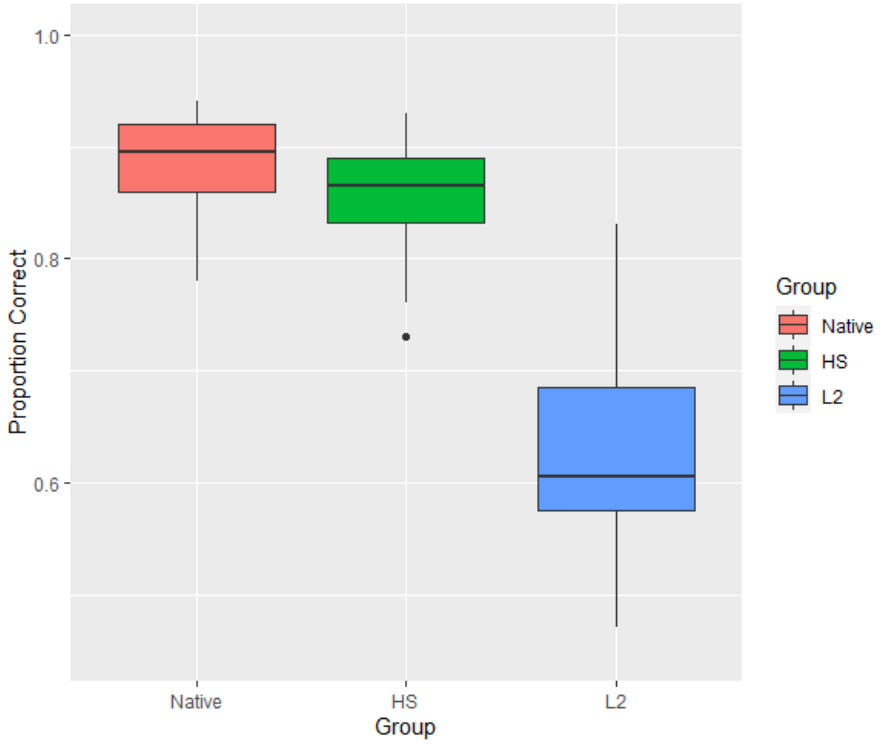

Figure 5. Boxplots showing the average perceptual accuracy by group in the AX discrimination task.

4.1.2 Speaker Effect

The results showed that the difference between Speaker 1 vs. Speaker 2 and 4 significantly affected the perceptual discrimination of the lenis–aspirated stop contrast by increasing the odds of accurate perceptual response by 2.66, and 2.50, respectively, when compared with Speaker 1 (Speaker 2: $\beta = .98$, $SE = .17$, $z = 5.92$, $p < .001$, Speaker 4: $\beta = .91$, $SE = .16$, $z = 5.55$, $p < .001$), adjusted for group and trial type. The results indicated that there was no difference between Speaker 1 and Speaker 3 in affecting the perceptual accuracy of participants (Speaker 3: $p = .06$). This indicates that when the lenis–aspirated stop contrast was represented by Speaker 1 and 3, participants found it more difficult to discriminate the contrast compared to stimuli recorded by other speakers. To investigate the effect of speaker, the current study examined the VOT and f0 as correlates of lenis and aspirated stops for each speaker separately (the whole set of stimuli: 72 items). A visual inspection of these values revealed that Speaker 1 had the greatest amount of variability in both VOT and onset f0 values of lenis stops among the speakers who recorded the stimuli, as plotted in Figure 6. Speaker 3, on the other hand, showed the least difference in the f0 values between the two kinds of stops among the speakers. This suggests that the increased variability and different cue assignment produced by Speaker 1 and 3, respectively, in the realization of these parameters as correlates of the lenis–aspirated contrast may have caused the perceptual difficulties experienced by the participants.

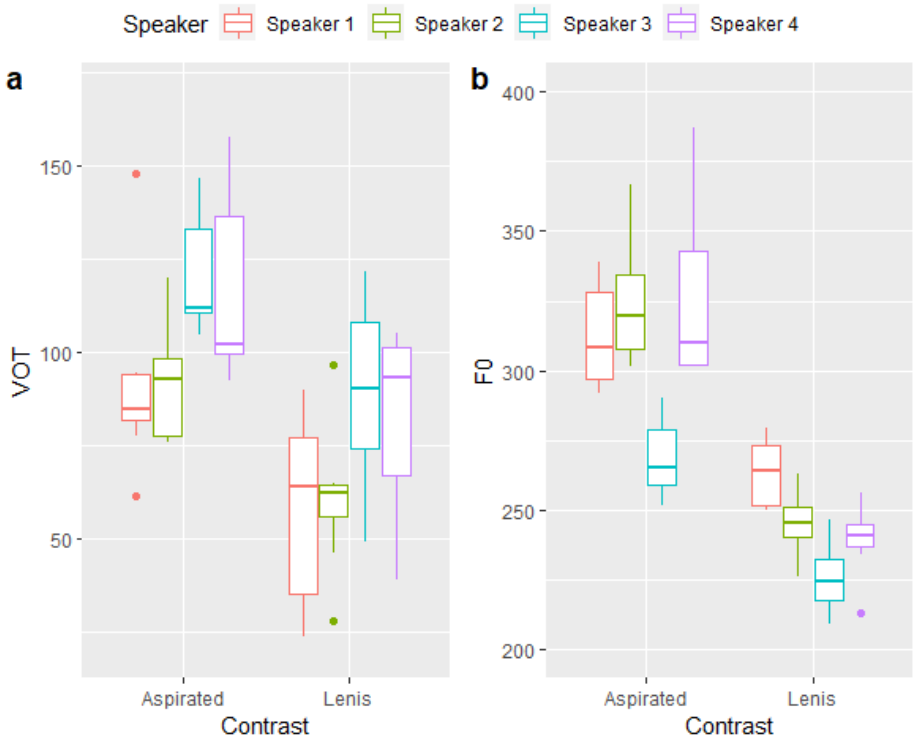

Figure 6. Box plots of the lenis–aspirated stop contrast separated by speaker. (a) and (b) show a comparison of VOT and f0, respectively.

4.1.3 Effects of Trial Type on Perceptual Accuracy

The effect of trial type (same-word trials / different-word trials) did not significantly affect the perceptual judgment in the AX task (p = .84). However, the fixed effect of the interaction between group and type was found to affect perceptual accuracy significantly in the same-word trials for the L2 group by increasing the odds of accurate response by a factor of 2.99 (β = 1.10, SE = .10, z = 10.56, p < .001). On the other hand, the HS group did not differ by the trial type when compared with the baseline group (p = .05). The results indicate that both the HS group and the baseline group performed comparably in the same- and different-word trials while the L2 group showed significantly lower accuracy in the different-word trials. This suggests that only the L2 group had a 'same' bias in the responses, indicating that the lenis–aspirated stop distinction was especially challenging for the L2 group of participants.

Figure 7 shows the average accuracy scores of each group by trial. There are three aspects of this figure that are worth mentioning. First, the average perceptual accuracy was higher in all groups in the same trials than in the different trials. Second, the L2 group shows the greatest

difference between the same and different trials. Third, even native speakers did not reach 100% accuracy in the AX task. This confirms that the lenis–aspirated stop contrast is perceptually difficult not only for L2 learners and HSs but for native speakers as well. Table 5 summarizes the results of the fixed effects in the mixed-effects logistic model.

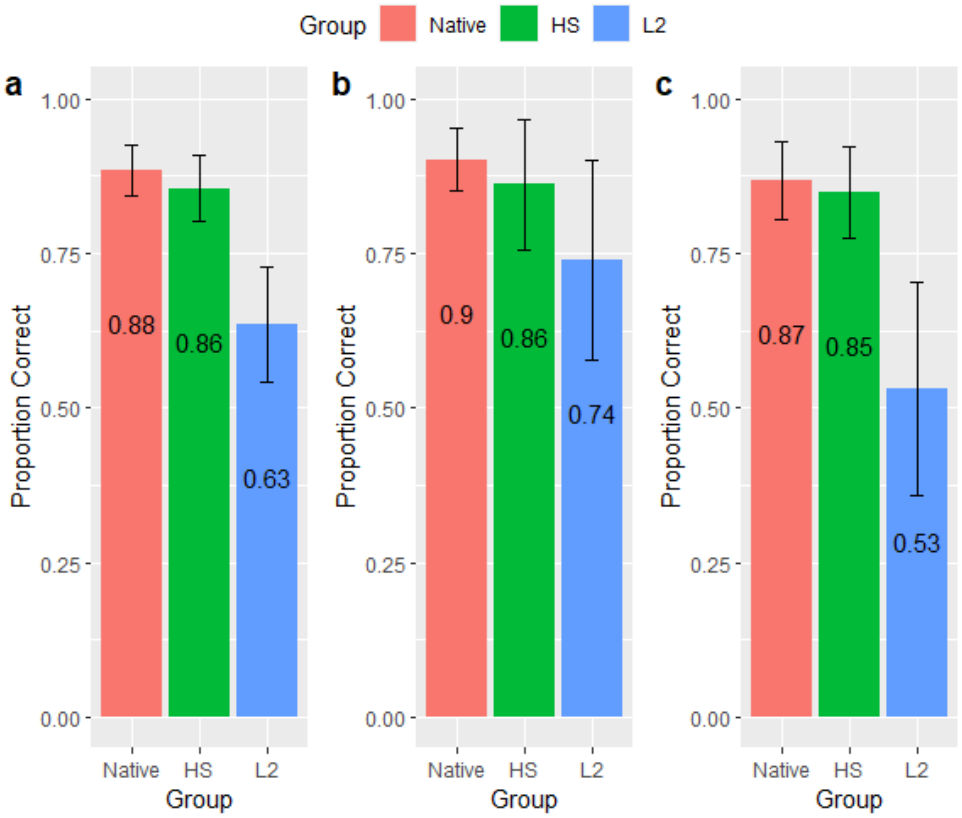

Figure 7. Bar plots of the average accuracy scores of each group by trial. (a) shows the average scores in both trial types, (b) shows the average scores in the same-word trials, and (c) shows the average scores in the different-word trials.

In addition to the group-level analysis, the current study examined the discrimination performance of each individual as seen in Figure 8, to uncover individual variability hidden behind the group patterns. As seen in the bar plots, 50% of the participants in the baseline group had accuracy scores of 90 or above, while only three in the HS group (15%) and none in the L2 group exceeded this level of accuracy. Not only does this finding show that HSs had a greater amount of individual variability than native speakers in perceptual accuracy, but it indicates that the discrimination task avoided the ceiling effect as none achieved near-100% accuracy. In addition,

comparing the HS group with the L2 group reveals that perceptual accuracy was generally higher in HSs than L2 learners; specifically, only one L2 participant exceeded 80% accuracy while there were only three participants in the HS group below this level of accuracy.

Table 5. Results of the first mixed-effects logistic regression model

	Estimate	SE	*z*-value	*p*-value	Odd ratio
Intercept	1.59	.17	9.24	< .001	4.90
GroupNative	.20	.17	1.18	.24	1.22
GroupL2	-2.01	.16	-12.33	< .001	.13
TypeSame	.03	.14	.20	.84	1.03
Speaker2	.98	.17	5.92	< .001	2.66
Speaker3	.30	.16	1.85	.06	1.35
Speaker4	.91	.16	5.55	< .001	2.50
GroupNative:TypeSame	.23	.12	1.95	.05	1.26
GroupL2:TypeSame	1.10	.10	10.56	< .001	2.99

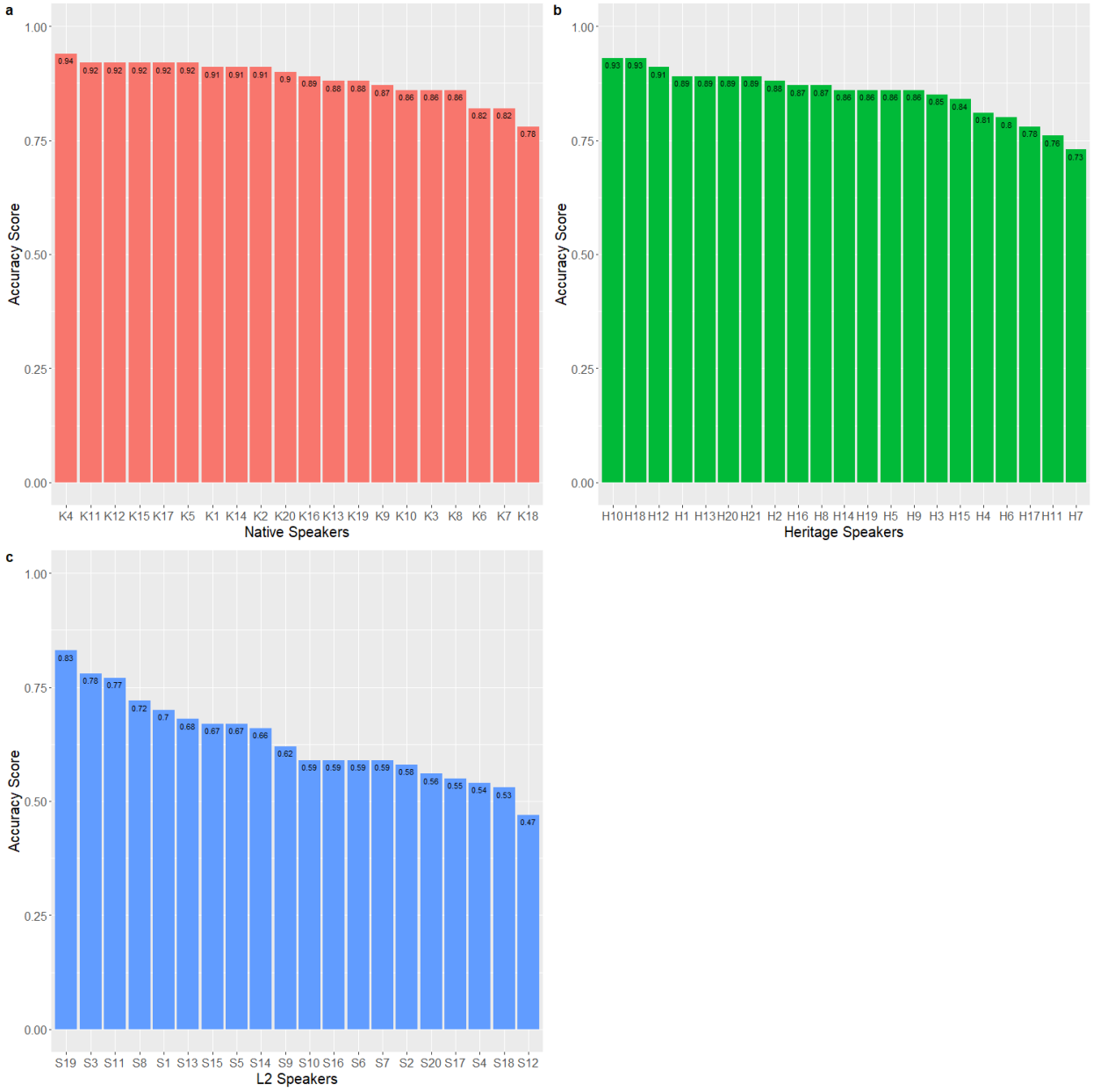

Figure 8. Bar plots of each individual on the x-axis with the y-axis of accuracy scores. (a) shows the baseline group, (b) shows the HS group, and (c) shows the L2 group.

4.2 Effects of Articulation Rate on Perceptual Accuracy

The second model was implemented to investigate the effects of background linguistic factors on the HSs' perceptual judgments in the AX task. The results showed that articulation rate significantly affected the perceptual accuracy of HSs by increasing the odds of accurate perceptual response by 1.83 as the articulation rate increased by 1 syll/sec ($\beta = .60$, $SE = .21$, $z = 2.92$ $p < .01$),

adjusted for other factors (see Figure 9). The result suggests that HSs who were more proficient in Korean were also more accurate in discriminating the lenis–aspirated stop contrast than those who were less proficient. In contrast, all other factors included in the model – AOA of English, percent Korean use, and percent Korean exposure – showed no significant relation to the perceptual accuracy in the AX discrimination task. Table 6 reports a summary of the fixed effects in the second model.

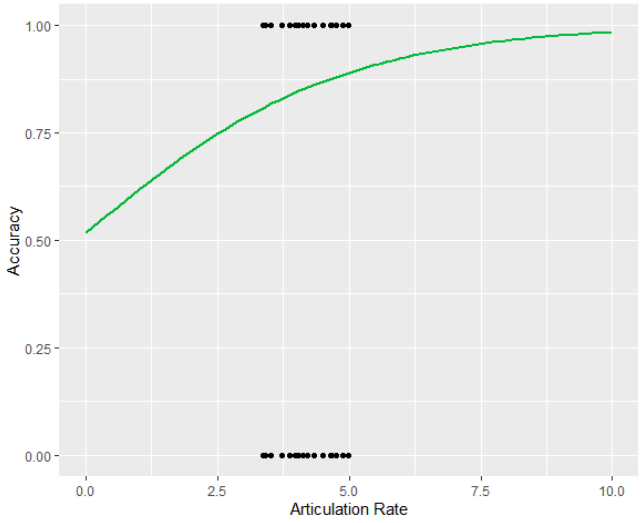

Figure 9. A predictive plot for the effect of articulation rate on perceptual accuracy from the second mixed-effects logistic model, demonstrating the relationship between articulation rate and perceptual accuracy in the HS group.

Table 6. Results of the second mixed-effects logistic regression model

	Estimate	SE	*z*-value	*p*-value	Odd ratio
Intercept	.03	.81	.04	.97	1.03
AOAEnglish	-.05	.05	-1.16	.25	.95
Use	-.00	.01	-.13	.90	1.00
Exposure	-.00	.01	-.36	.72	1.00
AR	.60	.21	2.92	< .01	1.83

The third model analyzed the L2 group and examined the effects of the background factors on perceptual judgment in the AX task. Although the independent variable of exposure was close to the significant level, none of the factors in the model were significantly related to the perceptual accuracy of L2 speakers. Table 7 summarizes the results of the fixed effects in the third model. Considering that the third model had a relatively small sample size (n = 16) due to the removal of

4 L2 participants, it is possible that this result arose from a small statistical power due to the small sample size.

For this reason, the current study further investigated the connection between background factors and perceptual accuracy by examining background variables of individual L2 and heritage participants. It was found that L2 learners who showed better performance in discriminating the stop contrast had generally greater exposed to Korean than those whose discrimination performance was less accurate. For example, the L2 participant S19, who showed the best discrimination performance in the AX task among all L2 participants, reported that she watches TV, reads, talks on the phone, and text in Korean very frequently (TV = 5, Reading = 5, Phone = 6, Text = 7 on a 7-point Likert-scale 1: never – 7: very frequently). Similarly, L2 participant S3 who was second best in the AX task reported that she chose to speak in Korean 50% of the time and was exposed to Korean 40% of the time on average in daily live. She also reported that she uses Korean very frequently at work on the same 7-point Likert-scale (Work = 6). On the other hand, L2 participants S12 and S18 who showed the lowest accuracy in the AX task in the L2 group reported that they were neither exposed to nor used Korean in daily lives. In short, L2 participants who were more accurate in the AX discrimination task had relatively more frequent exposure to and use of Korean than those who were less accurate in the same task.

Similarly, the individual analysis of HSs revealed a link between the use of Korean at home at the time of the experiment and participants' performance in the AX discrimination task. Specifically, HSs who used Korean at home more frequently performed better than those who used Korean less. For instance, H18 (Home = 5), H12 (Home = 4), and H1 (Home = 4) who were the most accurate in the AX task in the HS group reported that they used Korean frequently at home (on a 7-point Likert-scale, 1: never – 7: very frequently). In contrast, H7, H11, and H17 who scored the least in the AX task among the heritage participants reported lesser use of Korean at home (1, 3, and 1, respectively, on the same Likert-scale).

Table 7. Results of the third mixed-effects logistic regression model

	Estimate	SE	*z*-value	*p*-value	Odd ratio
Intercept	-.95	.88	-1.09	.28	.39
AOAKorean	.02	.01	1.64	.10	1.02
Use	-.00	.01	-.07	.94	1.00
Exposure	.02	.01	1.89	.06	1.02
AR	.25	.26	.94	.35	1.28

CHAPTER 5. DISCUSSION

5.1 Perceptual Abilities of Heritage Speakers

The first hypothesis of the current study was that HSs and L2 learners of Korean would show a decrease in perceptual accuracy of discriminating the Korean lenis–aspirated stop contrast in an AX discrimination task compared to native speakers in the home country. This hypothesis was based on several assumptions. First, the Korean lenis–aspirated stop contrast is proven to be perceptually and acquisitionally challenging due to its extensive reliance on onset f0 as a perceptual cue. Second, based on previous work in SLM, it was assumed that English and Korean laryngeal categories can affect each other, both in perception and production of bilingual speakers through the mechanism of equivalence classification because they are phonetically and phonologically similar but not acoustically identical sound categories. Therefore, the current study posited that, due to crosslinguistic influence from their dominant language, English, on Korean laryngeal stops, HSs as well as L2 learners would rely on the primary acoustic cue, f0, to a lesser extent in discriminating the contrast while relying on VOT to a greater degree than native speakers in South Korea, which will detrimentally affect discrimination.

The results of the experiment partially supported the first hypothesis, indicating that the HS group was on par with the baseline group in perceptual accuracy of discriminating the stop contrast despite the perceptually challenging nature of the contrast and their decreased Korean use and exposure as English became their dominant language since school age. On the other hand, the perceptual accuracy of the L2 group was significantly lower than that of the HS group, as well as that of the baseline group, as predicted, presumably due to their great reliance on VOT rather than onset f0, which is a primary cue in discriminating the English stop voicing contrast.

The second hypothesis of the current study was that the HS group would outperform the L2 group in perceptually discriminating the lenis–aspirated stop contrast in the AX discrimination task. This hypothesis was formulated based on HSs' acquisitional advantage of early language exposure and use compared to L2 learners. The results from the AX task confirmed the second hypothesis, demonstrating that the HS group outperformed the L2 group in all trial types (same-/different-word trials), which confirms the advantage of HSs in the acquisition of HL phonology. Specifically, the results suggest that the timing of L1 acquisition, as well as the quantity and the

quality of language exposure and use during infancy or early childhood, was sufficient to develop native-like perceptual abilities for HSs. This result adds to the body of research claiming that HSs are not disadvantaged compared to native speakers in terms of phonetic development (Chang & Mandock, 2019; Chang et al., 2011; Kim, 2020).

The results of the current study concur with previous research demonstrating native-like perceptual abilities of HSs despite a significant decrease in exposure to and use of their HL early in life. Although some studies showed under-performance in HL perception, compared to native speakers (Ahn et al., 2017; Cheon & Lee, 2013; Lee-Ellis, 2012), other studies also showed evidence for equivalent performance in perception between HSs and native speakers (Chang, 2016; Lukyanchenko & Gor, 2011; Oh et al., 2003; Tees & Werker, 1984; Werker, 1989). For example, Oh et al. (2003) demonstrated that Korean HSs were as accurate as native speakers at recognizing the three-stop categories in Korean (fortis, lenis, and aspirated stops) in a three-choice identification task. In other languages, Tees and Werker (1984) showed that English-dominant HSs of Hindi with little or no subsequent exposure to Hindi after the first couple of years since birth maintained their perceptual abilities to discriminate segmental contrasts which are not phonemic in English, such as [t] and [t̪] even decades after they had lived in the US (Tees & Werker, 1984). Another perception study by Lukyanchenko and Gor (2011) also showed HS's native-like perceptual performance to discriminate language-specific segmental contrasts in heritage Russian. The study also found that not only HSs of higher proficiency but those of lower proficiency outperformed L2 learners in discriminating phonemic contrasts.

Furthermore, the results suggest that English, a dominant language for the HSs, did not interfere with their categorical perception in discriminating the lenis–aspirated contrast in Korean as opposed to the L2 learners. This contrastive result calls for more explanation because it implies that the crosslinguistic influence from the same dominant language was imposed on L2 learners but not on HSs. Specifically, the result suggests that HSs are less susceptible to the crosslinguistic influence than L2 learners. This can extend to a claim that HSs can maintain and draw on both categories without as much interference as L2 learners.

In fact, some studies suggest that phonological perception is the least susceptible to L1 attrition for HSs among all linguistic domains, resulting in the most native-like performance, especially when compared to morphosyntax or even speech production (Chang, 2021; Oh et al., 2003). Thus, the result can mean that HSs who could access the Korean laryngeal categories with

less crosslinguistic interference than L2 speakers were truly equivalent with native speakers in their perceptual abilities to discriminate the lenis–aspirated stop contrast. This interpretation is especially likely given the relatively simple difficulty level of the AX discrimination task used in the current study since it was suggested that simpler tasks, such as AX discrimination, can elicit more comparable performance across groups (Lee-Ellis, 2012).

However, there can be alternative possibilities. That is, it could be the case that HSs relied on onset f0 to a lesser extent than native speakers while relying on VOT to a greater extent in discriminating the stop contrast as the current study predicted, but it did not adversely affect their discrimination performance, as opposed to the prediction. Although there were some studies suggesting that incorrect cue weighting in the perception of non-native contrasts can lead to non-native-like performance in discrimination (Yamada & Tohkura, 1990, 1992), there were also other studies showing that non-native cue-weighting in perceiving phonological contrasts does not necessarily result in non-native like discrimination. For instance, Escudero (2000, 2001) found that many Spanish speakers of L2 English performed equally well with native English speakers in discriminating the lax-tense vowel contrast in English, even though their cue-weighting to this contrast was significantly different from that of native speakers. They relied on the temporal cue to a greater degree than the formant frequency cue while English native speakers used the latter as a primary cue. Therefore, the alternative interpretation that the HSs in the current study performed on par with native speakers because the stimuli used in the AX discrimination task contained both onset f0 and VOT as acoustic cues to the lenis–aspirated stop distinction.

The acoustic analysis of the stimuli showed that the VOT merger between the lenis and aspirated stops was not as pronounced as expected, especially in the extreme ranges. This suggests that the HSs in the current study could have put more weight on this additional cue in discriminating the contrast to a greater degree than native speakers while also relying on the f0 cue, resulting in comparable performance as that of native speakers (see Chang & Mandock, 2019 for a similar reasoning). In fact, evidence from clear speech and child-directed speech studies indicate that the contrast between Korean lenis and aspirated stops produced in such contexts is distinguished by not only f0 but VOT to make the contrast as distinguishable as possible (Cheng, 2017; Kang & Guion, 2008; Kang & Nagy, 2016; Ko, 2018). Thus, it is possible that the laboratory setting caused unexpected clear speech in the production of speakers who recorded the stimuli, with the VOT distinction between the two kinds of stops emerging more clearly. As a result, this

additional cue could have benefited the HSs in discriminating the stop contrast, leading them to perform in the AX discrimination task with perceptual accuracy comparable with that of native speakers.

5.2 Linguistic Factors Affecting the Perceptual Accuracy of Heritage Speakers and L2 Speakers

The third hypothesis of the current study was that background linguistic factors can predict the perceptual accuracy of HSs and L2 speakers. To test this hypothesis, two separate mixed-effects logistic models (the second and third models) were implemented with each model of each group. The results partially supported the third hypothesis: only verbal fluency was found to be significantly correlated with the perceptual accuracy of HSs in discriminating the stop contrast among the linguistic factors examined in the current study. Specifically, those whose HSs articulation rate was higher showed more accurate performance in the AX discrimination task than those with a lower articulation rate.

The correlation between HSs' verbal fluency and perceptual accuracy concurs with previous literature claiming that HSs' verbal fluency is a valid indicator of their overall proficiency (Nagy & Brook, 2020; Polinsky, 2008, 2011; Polinksy & Kagan 2007). Importantly, this result suggests that crosslinguistic influence from English could be more pronounced in low-proficiency HSs than in high-proficiency HSs. Evidence from previous work indicates that more balanced bilinguals demonstrate a greater ability to maintain two separate sound systems than less balanced bilinguals, enabling them to minimize crosslinguistic influence between the languages (Barlow et al., 2013; Guion, 2003; MacLeod et al., 2009; Sundara et al., 2006). Therefore, the high-proficiency HSs in the current study could exercise better control over the interference from English in discriminating the Korean stop contrast, resulting in better performance than the low-proficiency HSs.

In contrast, none of the other linguistic factors, including Korean AOA, language use and exposure showed significant correlations with perceptual accuracy in the HS group. The results that HSs' AOA and language use and exposure did not affect HSs' perceptual accuracy are not new: this is a characteristic of HSs reported since the first study examining the phonological sensitivity to HL contrasts (Werker & Tees, 1984; Tees & Werker, 1984). Moreover, following studies have shown that HSs maintain their phonological abilities despite a decrease in use and exposure later in life (Chang & Mandock, 2019; Chang et al., 2011; Kim, 2020; Knightly et al.

2003; Lukyanchenko & Gor, 2011; Oh et al. 2003). Another plausible account for why the AOA of HSs was not associated with their perceptual accuracy can be found in their report on AOA. All participants of the HS group in the current study reported having started to acquire English at the age of 2 with little deviation (*SD* = 1.6). That is, the little variability in HSs' AOA led to a small power in the statistical analysis, not reaching the significant level in the effect of AOA on perceptual accuracy.

On the other hand, the result that none of the background factors were significantly correlated with perceptual accuracy in the L2 group is surprising because these variables have been documented to be associated with patterns of L2 speech perception (Flege, 1987, 1992, 1995 among others). One possible explanation could be the fact that the L2 group in the current study was very homogenous in terms of their linguistic background. Specifically, the great majority of the participants were late L2 learners with the mean age of acquisition of 22. Only four of these participants started to learn Korean before 18 years of age. This resulted in little variability in the AOA of the L2 group. Similarly, very few of them had any immersion experience with Korean, and as a result, their Korean proficiency levels were probably also very comparable. Insufficient variability in these dimensions may have precluded the possibility of establishing a statistical connection between these background factors and participants' discrimination performance. Another possibility is that the small sample resulted in low statistical power.

5.3 Limitations of the Study

Due to the COVID-19 pandemic, the current study was implemented online. This has raised three issues. First, since participants used their own hardware device to record the narrative task, the investigator could not control the quality of the production data. This has led to the removal of 6 participants (2 HSs and 4 L2 speakers) in the analyses due to the low quality of audio files and technical issues.

Second, the investigator could not control the noise during the perception task. Although participants were asked to perform the AX discrimination task in a noise-free place, the nature of online experiments does not allow for an investigator to have a complete control over the environmental noise during the experiment.

Third, it was impossible to implement proper participant screening in an online experiment. For example, 16 ineligible participants took part in the experiment but had to be excluded from the analysis.

Another limitation of the current study is the confusion in the use of unlabeled colored buttons when registering responses. Some participants reported that they were confused with which button to press under the time pressure on each trial. This confusion could have been prevented had the current study provided more practice trials or added labels (“same” and “different”) on the buttons.

CHAPTER 6. CONCLUSION

The current study investigated the possibility of crosslinguistic influence of English on the perception of Korean laryngeal categories by Korean HSs born and raised in the US and by English-speaking L2 learners of Korean residing in the US. The results of the AX discrimination task showed that HSs were as accurate as native speakers in discriminating the Korean lenis–aspirated stop contrast while outperforming L2 speakers. The study, therefore, concludes that the influence from English is lesser for HSs than for L2 learners. The current study attributes the perceptual abilities of HSs, comparable to those of native speakers, to the early use of and exposure to Korean. Categorical perception, an essential skill needed to acquire phonemes of one's language, develops as early as 8 to 10 months of age (Kuhl, 2005). Korean children as young as 2 years and 6 months old start to perceive and produce the lenis–aspirated stop contrast in a manner comparable to that of adult speakers (Choi et al., 2019; Jun, 2007; Kim & Stoel-Gammon, 2009). Moreover, speech perception is believed to be the least susceptible to L1 attrition (Chang, 2021; Oh et al., 2003). Based on the evidence, the results of the current study suggest that HSs' HL experience during early childhood is sufficient to develop and maintain native-like phonological perceptual abilities later in life.

APENDIX A. SURVEYS

How old are you (in years)?

What is your biological sex?

- ◯ Female
- ◯ Male

Please list all the languages you know in order of dominance: i.e. Korean, English

Please list all the languages you know in order of acquisition (your native language first): i.e. Korean, English

Please indicate what percentage of the time you are currently and on average exposed to each language. 0 = English, 100 = Korean

0 — 0 — 100

When choosing to read a text available in all your languages, in what percentage of cases would you choose to read it in each of your languages? Assume that the original was written in another language, which is unknown to you. 0 = English, 100 = Korean

0 — 0 — 100

When choosing a language to speak with a person who is equally fluent in all your languages, what percentage of time would you choose to speak each language? Please report percent of total time. 0 = English, 100 = Korean

0 — 0 — 100

How many years of formal education do you have?

Please check your highest education level (or the approximate US equivalent to a degree obtained in another country)

- [ ] Less than high school
- [ ] High school
- [ ] Professional training
- [ ] Some college
- [ ] College
- [ ] Some graduate school
- [ ] Masters
- [ ] Ph.D./M.D./J.D.
- [ ] Other (please specify)

Date of immigration to the USA, if applicable. If you have ever immigrated to another country, please provide name of country and date of immigration here.

Have you ever had a vision problem , hearing impairment , language disability , or learning disability ?

- [ ] No
- [ ] Yes
- [ ] Other (please specify)

At what age did you begin acquiring English?

At what age did you begin acquiring Korean?

For how long have you lived in a country where English is the main language in years and months?

For how long have you lived in a country where Korean is the main language in years and months?

Using the scale below, please rate your proficiency in English speaking.

Using the scale below, please rate your proficiency in understanding English.

Using the scale below, please rate your proficiency in English reading.

Using the scale below, please rate your proficiency in Korean speaking.

Using the scale below, please rate your proficiency in understanding Korean.

Using the scale below, please rate your proficiency in Korean speaking.

Using the scale below, please rate your proficiency in understanding Korean.

Using the scale below, please rate your proficiency in Korean reading.

In your perception, how much of a foreign accent do you have in Korean?

Please rate how frequently others identify you as a non-native speaker based on your accent in Korean.

Next

What is your country of birth?

If not US born, at what age did you move to the U.S? (If you were born in the U.S, skip this question)

For how long have you been living in the U.S?

What country do you currently reside in?

What is your first language?

Did you learn your first language from the birth?

- ◯ Yes
- ◯ No

What is the first language of your parents?

Which language(s) did you speak at home as a child?

What language do you feel most comfortable with at this time?

- ◯ Korean
- ◯ English
- ◯ Both

Which language(s) were you formally educated in primary school/high school/college?

At school, the present contact with Korean and English is

At home, the present contact with Korean and English is

At work, the present contact with Korean and English is

At social situations, the present contact with Korean and English is

Do you have a Korean-speaking partner?

- ◯ Yes
- ◯ No

If so, how frequent do you speak Korean with her/him?

How frequent do you speak Korean over the phone?

How frequent do you text /chatin Korean (Kakaotalk, Line, Skype, other apps)?

How frequent do you speak Korean to your mother?

How frequent do you speak Korean to your father?

How frequent do you speak Korean to your grandparents?

How frequent do you speak Korean to your siblings?

How frequent do you speak Korean to your friends at school or community?

How frequent does your mother speak Korean to you?

How frequent does your father speak Korean to you?

How frequent does your grandparent(s) speak Korean to you?

How frequent does your sibling(s) speak Korean to you?

How frequent does your friend(s) speak Korean to you?

How frequent do you watch TV in Korean?

How frequent do you read in Korean? (printed and online materials)

Next

If you were recruited via Prolific, please provide us with your Prolific ID below: (If not, please say "no")

If you were recruited by other than Prolific, please provide us with your email account for a gift coupon.

Next

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