VOT merger and f0 contrast in Heritage Korean in California

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Abstract

Recordings of read speech in Korean and English were made by native South Koreans and Korean Americans of varying generational status ("second-generation" American-born or "1.5-generation" foreign-born) and analyzed for differences in usage of VOT and fundamental frequency to contrast production of Korean lenis and aspirated stops and affricates. The speech was then played back to listeners of Korean heritage and judged metalinguistically regarding proficiency in Korean and other attributes relevant to the speech and demographics of immigrant speakers. Results show that second-generation Korean speakers, especially females, are not showing the collapse of VOT contrast found in the other two groups, one part of the "tonogenetic" sound change nearing completion in Seoul. Female second-generation speakers are also not using f0 to differentiate between the stops to the extent that first- and 1.5-generation speakers are. These second-generation speakers were easily identifiable as having been born in the United States, but the correlation with their generational identification and use of VOT and f0 to contrast lenis and aspirated stops and affricates is mild. It is concluded that because second-generation Korean Americans vary in their production of Korean, there is no clear sociophonetic marker for a Korean American "variety" of the language. The most proficient second-generation speakers closely resemble native speakers and do demonstrate the tonogenetic sound change, but the least proficient second-generation speakers diverge from this norm in a variety of ways. Second-generation Korean American speakers are easily identifiable as not speaking in the same way as native South Korean speakers, although this does not hinge on their use of the f0 contrast. The analysis makes a stronger case for applying new models of language acquisition, speech production, and identity formation to heritage language speakers that differ from those used for bilingual speakers.

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1 Introduction

This paper is organized as follows: The introduction has three sections, the first of which describes a current sound change occurring in Seoul Korean and the second two of which explain how heritage language speakers vary in language competence and review the sociolinguistic literature on heritage Korean speakers. Sections two and three describe the methods and results of the production half of the study; sections four and five describe the methods and results fo the perception half of the study. These are followed by an overall discussion and a conclusion, including outstanding questions and possible avenues for future research.

1.1 Tonogenetic Sound Change

Korean possesses a three-way contrast in manner of articulation that has been described as "laryngeal" or a "phonation contrast" (Kim-Renaud, 2014; Cho et al., 2002) that is typologically unique in its manifestation. The phonemic stops and affricates that demonstrate this contrast are most commonly called lenis, fortis, and aspirated. Though phonetic descriptions of each type of consonant is variable in the present literature, it is generally agreed upon that differentiation across acoustic properties lies primarily in voice quality (H1-H2), VOT, and fundamental frequency (f0) of the subsequent vowel, among other acoustic and aerodynamic attributes (Cho et al., 2002; Han and Weitzman, 1970). The current study focuses on two acoustic properties, VOT and f0, and draws from the evidence for a sound change in progress that is changing how these properties are used by certain populations of Korean speakers in production and perception of lenis and aspirated stops and affricates.

	bilabial	alveolar	post-alveolar	velar
nasal	m /m/	n /n/		
lenis stop/affricate	b /p/	d /t/	j /tɕ/	g /k/
fortis stop/affricate	bb /p͈/	dd /t͈/	jj /tɕ͈/	gg /k͈/
aspirated stop/affricate	p /pʰ/	t /tʰ/	c /tɕʰ/	k /kʰ/
non-tense fricative	s /s/			
tense fricative	ss /s͈/			

Table 1: Simplified Korean consonant inventory emphasizing the three-way "laryngeal" stop contrast: lenis, fortis, and aspirated. Standard IPA symbols are indicated between slashes; I have used a single subscript vertical stroke to represent the tense consonants.

When lenis stops and affricates occur utterance-initially or word-initially, they undergo a VOT-lengthening process that results in aspiration (Silva, 2002, 2006b), as shown in Table 2 below. This makes word-initial lenis stops more similar to aspirated stops, but a contrast

is still maintained. In the past, this has taken the form of a three-way VOT contrast (fortis with the lowest VOT, aspirated with the highest VOT, and lenis in between)[1].

	mean VOT	Word	IPA	Gloss
lenis	65.2 ms	*bul*	/pul/ [pʰul]	'fire'
fortis	10.2 ms	*bbul*	/p̥ul/ [p̥ul]	'horn'
aspirated	73.7 ms	*pul*	/pʰul/ [pʰul]	'grass'

Table 2: Mean VOT values for phrase-initial stops, from Silva (2006b); lenis stops' VOT approaches aspirated stops' VOT in this phonetic context.

However, recent studies of the variety of Korean spoken in the capital city Seoul and its surrounding region, Gyeonggi-do, have shown that the phonetic difference between word-initial lenis and aspirated stops along the dimension of VOT is collapsing. In its place, speakers are increasing usage of f0 of the subsequent vowel to distinguish aspirated from lenis: aspirated stops and affricates have a higher pitch than lenis (Silva, 2006a,b; Kang and Guion, 2008). This pitch difference has been accounted for in the earliest studies of Korean, but according to Silva (2006a), it was intrinsic and even considered 'redundant', as it was not used as the primary contrast marker. With the apparent diminishing of the VOT dimension of distinction between aspirated and lenis, then, pitch is rising to take its place; the parallel changes in VOT and in f0 are presumed to have happened closely or "in tandem" (Bang et al., 2015). The has been shown in production as well as perception (Kim and Beddor, 2002; Kim, 2004). In addition to age and generational differences (where younger speakers are advancing the change), female speakers lead over male speakers (Oh, 2011), Seoul and northern metropolitan speakers lead over southern (regional dialect) speakers (Choi, 2002), and, potentially, speakers with L2 proficiency in English lead over those without (Kim, 2013).

The emergence of pitch as the primary means of contrast may have begun as recently as two generations ago (Kang and Han, 2013); the contrast is found and categorical in most younger speakers of Seoul Korean, therefore signaling sound change near completion. All speakers born later than 1960 in the corpus study of Kang (2014) show the change in word-initial f0 distinction, though only females born earlier (as early as 1940) showed the change, possibly indicating that they were the vanguard. The timing was approximately the same for the change in VOT distinction; all speakers born from 1960 to 1980[2] show a smaller aspirated-lenis VOT difference, with females again leading in the directionality of change. However, interspeaker variation in this sound change still exists in Seoul Korean, and low-frequency words are still less likely to manifest either aspect of the change (Bang

[1]Most romanization systems for Korean use '*b,d,g*' for the lenis stops and '*p,t,k*' for the aspirated stops, as I do here. However, at least word-initially, all of these stops are voiceless. Romanization is indicated by italics and will be used in place of IPA henceforth.

[2]No speakers in the National Institute of the Korean Language corpus were born after 1984.

et al., 2015). Some studies refer to this phenomenon as tonogenesis, or a tonogenetic sound change, but it is clear that Korean has not developed phonological or lexical tone in the manner of prototypical tone languages, at least not yet.

Most of this research has been limited to native speakers of Korean who reside in the regions where the sound change is understood to have originated. In one recent study, however, the speech of diasporic Koreans was tested for the presence of pitch contrast between lenis and aspirated stops and affricates. Kang and Nagy (2016) extracted VOT and f0 data from conversational speech in a corpus and analyzed the measurements in relation to demographic factors such as generational cohort ("first-generation" or "second-generation") and gender. They found that Koreans born and raised in Toronto differentiated lenis and aspirated stops and affricates in production with a VOT merger and pitch contrast that resembled "homeland Korean" speakers, but not to the extent of an exact replication. (Hrycyna et al. (2011) found similar evidence of "VOT drift" toward English in a group of Russian and Ukrainian Canadians up to the third generation of immigration.) These "heritage speakers", in our case the second-generation Korean Canadians, are of particular interest, because their ethnicity and common language link them to peninsular South Koreans, yet the unique circumstances of their heritage language (henceforth 'HL') input, language environment, and multicultural identity could be the basis for an interesting twist on the "transition problem" (Weinreich et al., 1968): namely, these factors may collude to inhibit the generational transmission of the sound change in question.

1.2 Heritage Korean: Variability in acquisition

Recent research indicates that heritage speakers' competence in the HL is affected by contact with the dominant language (English) and orientation toward the dominant culture. However, can all heritage speakers be modeled in the same way? We must make room for a wide range of interspeaker variability.

Jean and John[3] are two Korean Americans that I know. Both were born and raised in Southern California and were exposed to spoken Korean at an early age by parents who immigrated from South Korea. Jean has retained a high level of competence in Korean in her adulthood, using it daily with her family and slipping in code-switched Korean words and phrases when chatting with her Korean American friends, both in person and online. John, on the other hand, hardly speaks Korean, having used only English to communicate with his parents since he began his schooling. His grasp of Korean is limited to common greetings, certain foods, and kinship terminology; he knows, for example, that he should address the pastor's wife as *samonim* but cannot hold a conversation with her.

The hundreds of thousands of second-generation Korean Americans in this country all fall

[3]Pseudonyms are used.

somewhere along this spectrum between Jean and John: they may be natively fluent or speak at the level of a young child; they may have had years of formal Korean classes or never have heard the language beyond the walls of their home. Yet all of them have this common heritage: their knowledge of Korean comes from within their first and closest social network[4].

How should we model the phonological system of a heritage speaker of Korean? It seems likely that a spectrum of models is better suited to the task than just one, especially if the one is based purely on a common model of bilingual phonology. Heritage speakers are not only different from sequential bilinguals, but more diverse. The narrow definition of a heritage speaker (Polinsky and Kagan, 2007; Wiley and Valdés, 2000) establishes it as an individual who was raised in a home hearing and speaking an L1 first, but did not completely acquire it due to having switched to L2 dominance early on. The individual retains some degree of bilingualism in both languages. Even when adopting this narrow definition, however, the net is cast wide. One must take into account more than just the occurrence of early childhood HL input due to the depth of the variety of input.

For instance, there is the axis of childhood perception of a language (i.e., a caregiver uses the language in the household, directed at the child or not), and then there is the axis of active child use of a language. Every parent-child situation will differ in the amount of each that goes into the child's phonology, as well as the quality of the input (Flege, 2007; Domínguez, 2009). An important common finding is that childhood "overhearers" will behave differently from childhood speakers in production and perception; this has been demonstrated for heritage speakers of Spanish and Mandarin (Au et al., 2002; Chang et al., 2011). In general, however, it has been argued that heritage speakers are the most successful at maintaining both language-internal and cross-linguistic phonetic contrast, due specifically to that early exposure (Chang et al., 2011; Chang, 2016; Jia et al., 2006)[5]

For Korean specifically, Lee et al. (2006) showed that childhood speakers were as good as native speakers in perception and production of the tense-lax-aspirated contrast, and childhood hearers outperformed novice Korean learners in perception but not production. For Korean-English sequential bilinguals, the age of acquisition of English influences the VOT of stops produced in both languages; early sequential bilinguals appeared to have two separate systems for Korean stops and English stops, while late bilinguals demonstrated a

[4]Thanks to Sharon Inkelas for pointing out that some heritage learners will have studied the language in university courses, presumably by teachers who speak a standard variety of Korean, which may have consequences on how the VOT and f0 tradeoff plays out in their speech. These are in fact the kinds of speakers studied in H.S. Kim (2001), among others. It remains to be seen how Korean heritage speakers with formal Korean education participate in the sound change compared to Korean heritage speakers without formal language training and non-Korean Americans who learn Korean as an L2.

[5]Note that acquisition of phonology is by no means the only dimension along which heritage or bilingual acquisition studies are done; see Montrul et al. (2008); Polinsky (2008) for examples and Rothman (2009) for a review.

merged system (Kang and Guion, 2006)[6].

These studies are oriented toward L1/L2 acquisition, which brings up two important points of consideration. First, they tend to categorize heritage speakers as bilingual speakers, when they should really be separated, as the most recent sociolinguistic and sociophonetic studies are now doing. Secondly, they understandably neglect to factor in the social aspect of language and the influence of identity, using only objectively measurable variables, such as age of acquisition, to model linguistic behavior[7]. Fortunately, there is a wealth of recent research that aims to show that language, as a means of self expression and not just a hard-wired mechanism that gives output x based on input y, should be influenced just as strongly by culture and identity. Jean and John's linguistic behavior may differ due to when they each acquired English and Korean, but their full stories are much more complex.

1.3 Heritage Korean: Speech and identity

The first major study of second-generation Korean Americans regarding use of their heritage language was conducted by Cho, Cho, and Tse in 1997. All interviewees were classified as English-dominant and were enrolled in a college-level Korean language program. Among the reasons given for their desire to learn or improve their fluency in Korean were developing relationships with parents and relatives who spoke Korean but little to no English, preserving their ethnic identity, and taking advantage of increased job opportunities both in the United States and abroad.

Cho et al. (1997) also found that Korean Americans exhibited some amount of shame that correlated with lower language ability (although as a reminder, this study focused on those Korean Americans who had clearly taken steps to improve their Korean). Yet even among Korean Americans not necessarily engaging in HL education, as in Lee (2002), most respondents felt that their own proficiency in Korean was not enough, and that lack of societal recognition of the importance of maintaining the heritage language was a large contributor to their attrition or general lack of proficiency. Shin (2005) looks closely at the internal and external pressures on Korean American families that influence how the second generation is raised, successfully or not, to be bilingual.

Of course, we should not expect heritage speakers to exhibit a proficiency equal to that of native speakers or even accept the "standard" variety of the language as a baseline

[6]Note that the speakers in this study were not categorized as heritage speakers, though some of the "early sequential bilinguals" may have been, according to the working definition.

[7]Chang et al. (2011) did acknowledge that the finding of statistically robust differences despite the hetereogeneity in language use and proficiency in the sample of speakers is a good indicator that the correlation between successful contrast maintenance and childhood exposure holds even when personal identity or other kinds of interspeaker variation are not accounted for.

from which to judge[8]. Polinsky and Kagan (2007) provides a good argument that heritage speakers are best modeled as falling along a continuum from near-native to barely-proficient, which is important because it throws a necessary wrinkle into any models of heritage language production.

In addition, as heritage speakers have all received different levels and modes of input, it is only fair to judge each one according to that input, rather than, for example, according to the standards of the heritage country. Heritage Korean speakers, for example, were found to be less aware of and less proficient in use of different formality registers (H.S. Kim, 2001), likely due to the fact that only one or two formality registers (out of six in the language) would be used in the home. This pattern is prevalent not just in Korean immigrant communities, but in nearly all minority language communities in the United States (Wiley, 2001), often resulting in situations of a communication breakdown and social and interfamilial conflict (Wong Fillmore, 2005).

Taking this into consideration, Lee (2002) found that proficiency of HL speakers was in fact closely tied with a sense of "bicultural identity" – that is, a speaker who identifies in equal amounts with the dominant (American and English-speaking) and heritage (Korean) cultures would have greater proficiency than one whose sense of self was more acculturated to American identity. This itself, presumably, is influenced by language ideologies and cultural and linguistic practices in the home of Korean Americans, including parental attitudes toward Korean language and culture, the parent-child relationship, and the age of acquisition of English via immersion (Park and Sarkar, 2007; Jeon, 2008; Au and Oh, 2009; Song, 2010).

However, we are also beginning to see a "third-wave" shift in the type of lens used to study the indexes of particular language use: arguments like those in Jeon (2008) and Kang (2015) that the presumed correlations between demographic data and language use are explanatory but not necessarily prescriptive, and that the "heritage identity" is, like all other social identities, always in a state of renegotiation depending on the situation. That is to say that any given Korean American's speech and use of Korean is modulated by factors as fine-grained as a particular social situation with certain interlocutors at a certain time of day.

What all this tells us, then, is that however Korean heritage speakers today are using and understanding their languages, their practice is mediated through quite a number of complex and interlacing social factors. Attitudes toward American culture and the English

[8]Thanks to Andrew Garrett for pointing out that the distinction between heritage and "native" speakers may imply that heritage speakers are "non-native". I do not mean to make the implication that a heritage speaker of Korean is a non-native speaker of Korean, especially not in the same way that I, for example, am a non-native speaker of Korean. However, I do maintain that there is a difference between the native (Seoul) Korean speaker community and the heritage Korean speaker community, one that requires "non-native" in this study to mean "not from Seoul, South Korea"

language, and Korean language and culture, not to mention the perception of native and foreign accents, will all be filtered through multiple lenses.

Thus, this study attempts to address two sociolinguistic questions. The first is whether or not second-generation speakers of Korean, the heritage speakers who maintain at least basic fluency, exhibit the same age-graded variation as their peers in Seoul or more resemble the family members from whom they learned Korean. While Kang and Nagy (2016) gives precedent for second-generation Koreans to mostly adopt the sound changes from Seoul, the current study looks at Korean Californians who belong to a younger cohort. The age difference is important here, because if Kang and Nagy were correct in predicting a reversal in the tonogenetic sound change in the younger generation, then this should be born out in the Korean Californian heritage speakers. The prediction is that while recent young immigrants from South Korea will exhibit the VOT merger and f0 contrast, young Korean Californians will not exhibit as much of it, perhaps even less than the (older) Korean Canadians did.

However the Korean Californians behave, their participation in the sound change or lack thereof will raise additional questions, such as how their identity as "second-generation" or "children of immigrants" may be indicated or marked by the sociophonetic variables of VOT merger and f0 contrast. This variable is certainly not yet a linguistic stereotype, but it may already index "Korean-ness" to a certain group or sub-group of Koreans. Secondly, the attitudes second-generation Koreans have toward language may be explored to theorize how an individual's navigation of identity is reflected in their use, perception, and understanding of language. Variation in amount of participation in the sound change is expected, but it is predicted that a stronger orientation toward Korean language and culture will correlated with greater participation, in line with the findings of various HL proficiency studies (Lee, 2002; Jeon, 2008; Kang, 2015).

2 Production: Methods

The first experiment of the study compares native Korean speakers with heritage speakers, with generational status used as a stand-in for heritage speaker identity. Koreans who had immigrated to California from Seoul at age 15 or later were categorized as first-generation (G1), and those born in America or who had moved permanently before the age of 2 were categorized as second-generation (G2)[9]. A number of subjects were born and raised in South Korea but immigrated to the United States between the ages of 2 and 14, or had

[9]Although the literature is not consistent with respect to the question of exactly when an infant's L1 phonology has been concretized enough to influence an L2, it has been shown that by two years of age, bilingual children have established separate (though nonautonomous) phonological systems for their languages (Paradis, 2001); also see Lleó and Kehoe (2002).

moved back and forth between the United States and South Korea (and sometimes other countries). These were included in the 1.5-generation category (G1.5)

Admittedly, using age of immigration as a way to categorize speakers is really just a half-way sort of compromise between using age of acquisition of English and asking speakers outright how they self-identify[10]. However, it is a common quick diagnostic that Korean Americans themselves use to sort the young people in their community (see Park, 1999; Kim and Duff, 2012).

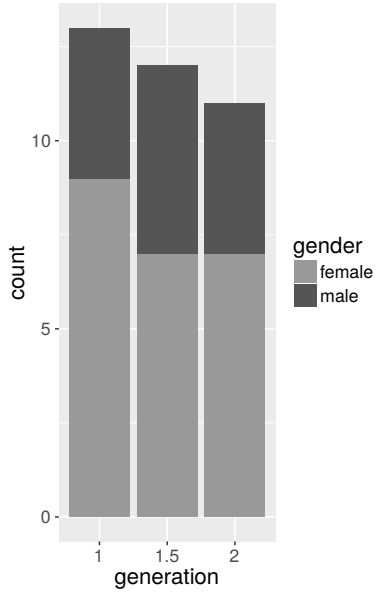

Figure 1: Participants in the production experiment.

Thirty-two native and heritage Korean speakers (22 female, 10 male, average age 21.28) were recruited for the production experiment and compensated monetarily for their participation. The participants recorded Korean minimal triplets within the carrier phrase "*Naneun ___(i)rago haeyo* (I am saying/called ___)," and then in constructed sentences that used the target words in a natural context.

All participants also recorded a series of English words in carrier and contextualized sentences for use in a parallel study; the Korean stimuli and English stimuli were blocked in the same session. All of the speech was recorded in a sound-attenuated booth using a [type of mic] microphone.

Table 3 below lists the target words, which were selected to provide a variety of vowel contexts and word frequencies. Although most studies of the three-way laryngeal contrast include bilabial, alveolar, and velar stops, this study also included the post-alveolar[11] affricates[12].

[10] And as a further note, age of immigration as a variable only correlates to date or year of immigration if all subjects, like those in this study, are of a similar age range. Subjects who immigrated at age 18 in 2015 may differ from subjects who immigrated at age 18 in 1980, depending on whether certain phonetic changes take a set amount of time to learn or can only be learned before a certain period in (historical) time. So far, unfortunately, no "older" G1 speakers are present in the sample to really test this hypothesis.

[11] Or alveolar – see H. Kim (2001).

[12] See (Chang, 2013) for a discussion of utterance-initial Korean fricatives, which can be characterized as 'fortis' and 'non-fortis'. (He argues for a fourth laryngeal category that combines lenis and aspirated characteristics for Korean /s/.) As the categorization of the non-fortis alveolar fricative is still the subject of much debate, it will be not be included in the current study.

lenis	fortis	aspirated
bal /pal/ 'foot'	*bbal* /p͈al/ 'to suck'	*pal* /p^{h}al/ 'arm' or 'eight'
bat /pat/ 'field'		*pat* /p^{h}at/ 'red bean'
bul /pul/ 'fire'	*bbul* /p͈ul/ 'horn'	*pul* /p^{h}ul/ 'grass'
dang /taŋ/ 'political party'	*ddang* /t͈aŋ/ 'land'	*tang* /t^{h}aŋ/ 'soup'
deol /tʌl/ 'less'	*ddeol* /t͈ʌl/ 'to shake'	*teol* /t^{h}ʌl/ 'fur'
deulda /tɯl.da/ 'to enter'		*teulda* /t^{h}ɯl.da/ 'to turn on'
jang /tɕaŋ/ 'page'	*jjang* /tɕ͈aŋ/ 'super'	*cang* /tɕ^{h}aŋ/ 'window'
jada /tɕa.da/ 'to sleep'	*jjada* /tɕ͈a.da/ 'salty'	*cada* /tɕ^{h}a.da/ 'to kick'
jejo /tɕɛ.dʑo/ 'manufacturing'		*cejo* /tɕ^{h}ɛ.dʑo/ 'gymnast'
jinjja /tɕin.tɕa/ 'really'	*jjinbbang* /tɕ͈in.p͈aŋ/ 'bun'	*cingu* /tɕ^{h}in.gu/ 'friend'
gan /kan/ 'liver'	*ggan* /k͈an/ 'peeled'	*kan* /k^{h}an/ 'train car'
geu /kɯ/ 'that'	*ggeu* /k͈ɯ/ 'to turn off'	*keu* /k^{h}ɯ/ 'large'
gul /kul/ 'oyster'	*ggul* /k͈ul/ 'honey'	*kul* /k^{h}ul/ 'cool'

Table 3: Minimal pairs and triplets for Korean word-initial stops and affricates.

Because the speakers were given a reading task, they had to have basic reading fluency in Korean. The greatest variation in reading fluency was in the G2 group of speakers, some of whom struggled with the less frequent words in the stimuli. On a three-point scale of fluency, all speakers self-rated their speaking, listening, and reading skills. All G1 speakers gave themselves threes across the board, but G2 speakers had an average self-rated speaking proficiency of 2.1 and an even lower reading proficiency of 1.7, as shown in Table 4. G2 speakers also had the greatest variation in self-ratings, as evidenced by the higher standard deviations.

group	speaking	listening	reading
G1	3.0 ± 0	3.0 ± 0	3.0 ± 0
G1.5	2.8 ± 0.45	2.9 ± 0.29	2.9 ± 0.29
G2	2.1 ± 0.7	2.5 ± 0.52	1.7 ± 0.65

Table 4: Self-given ratings of proficiency by members of each generational group

Recordings were manually checked for quality and were then force-aligned using kp2fa (Yoon and Kang, 2014), a TextGrid-alignment program that uses the HTK-Toolkit (Young et al., 2006), and then analyzed using an Inverse Filter Control formant tracker (Watanabe, 2001) and an automatic VOT measuring tool (Keshet et al., 2014). TextGrids and some measurements were hand-corrected using Praat (Boersma and Weenink, 2016) and then visualized and run through statistical tests using the relevant packages in R (2016).

3 Production: Results

3.1 Voice Onset Time

The results in this section are taken from measurements of the Korean target words spoken in carrier sentences. A two-way repeated measures ANOVA found a significant effect of generational group on the VOT of word-initial aspirated stops and affricates ($F(2, 774)=3.923$, $p=0.032$). Independent t-tests confirmed that all three generational groups differed significantly in their aspirated VOT ($p<0.005$ for all three comparisons). The ANOVA did not find a significant effect of generation on lenis VOTs ($F(2, 776)=1.114$, $p=0.342$), indicating that the three groups' mean VOTs were roughly the same for lenis stops and affricates. Figure 2 charts the mean VOT of each consonant type for each generational group, split by gender (although statistical tests were run on pooled data).

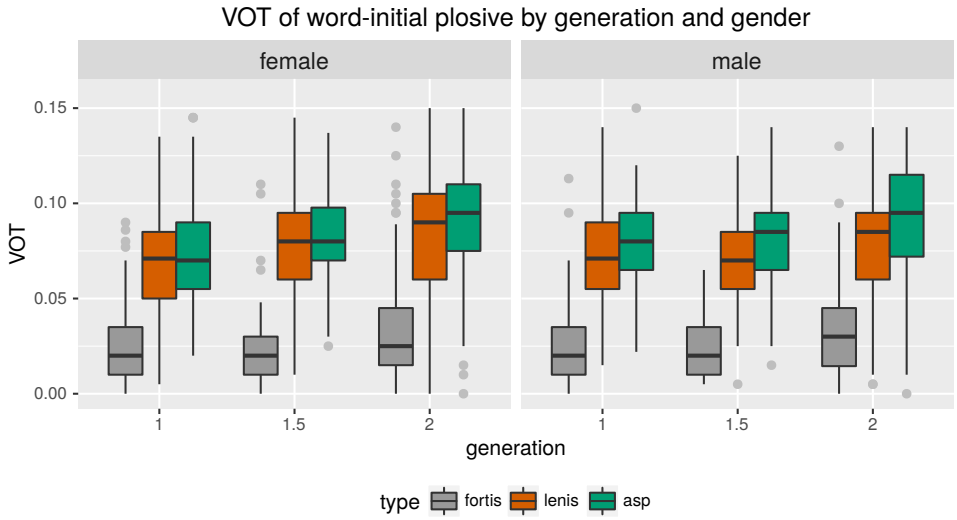

Figure 2: VOT of word-initial stops and affricates by generation and gender.

Because the change in VOT is described as a merger, or a collapse in contrast, the mean difference in VOT between aspirated and lenis stops was calculated for each generation. If the VOT difference is zero or close to zero, this indicates a collapse in contrast. The mean VOT differences of the three groups were 0.0052 (G1), 0.0078 (G1.5), and 0.0122 (G2). The difference is objectively greater for the G2 speakers, although independent t-tests and an analysis of variance examining VOT difference among generational groups found no significant difference or significant effects of generational group.

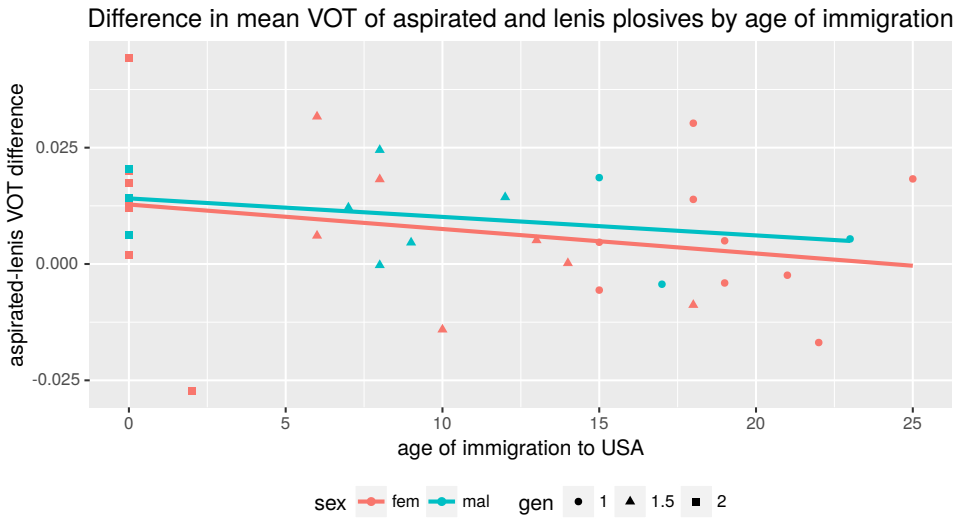

Figure 3: VOT difference of word-initial aspirated and lenis stops and affricates by age of immigration to USA; a significant effect of age of immigration was found ($F(1,32)=4.953$, $p=0.033$).

However, when evaluating the VOT difference as a function of age of immigration to the US (which is the discrete variable that determines how binning was done for each generational group[13]), a significant effect of age of immigration was found ($F(1,32)=4.953$, $p=0.033$). Speakers who immigrated at a younger age showed less of the VOT merger than those who immigrated when they were older, as shown in Figure 3.

This significant result was likely carried mostly by a significant effect of age of immigration on aspirated consonants ($F(1,774=7.38$, $p=0.011$), but not lenis consonants ($F(1,774)=0.64$, $p=0.43$)). Thus, it is mainly a difference in the production of aspirated consonants that distinguishes the G2 speakers (and/or the speakers who immigrated at a younger age or who were born in the United States) from the others.

3.2 Fundamental Frequency

Fundamental frequency (f0) data were not normalized for gender, so female-identifying and male-identifying speakers were analyzed separately. There was a significant effect of generation found for aspirated f0 in women ($F(2, 174)=22.65$, $p<0.001$), but a barely

[13]There are advantages to using age of immigration as the dependent variable rather generational group, the most prominent of which is perhaps the greater statistical power afforded by using a semi-continuous variable instead of bins. With more subjects and a more precise definition of "generation", however, the generational groups would also be very useful in modeling Korean Americans' speech production patterns.

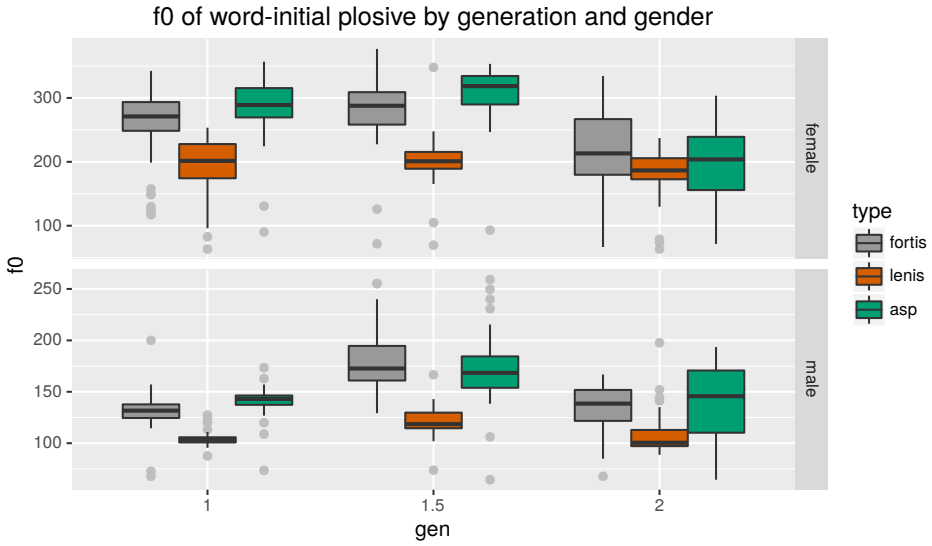

Figure 4: VOT of word-initial stops and affricates by generation and gender.

non-significant effect for aspirated f0 in men ($F(2, 96)=3.7$, $p=0.073$). Independent t-tests confirmed that the G2 female speakers had significantly lower measurements for both aspirated and lenis f0 ($p<0.0001$ and $p=0.0054$, respectively), even though the analysis of variance did not show a significant effect of generation for lenis f0. However, male speakers did not pattern in the same way by generation: it was the G1.5 male speakers who differed from the other two groups, having a significantly higher f0 for all three phonation types than G1 and G2 speakers, as can be seen in Figure 4.

It becomes quite clear that female speakers pattern differently from male speakers when the aspirated-lenis f0 difference is analyzed. Given the tonogenetic sound change, native Seoul Korean speakers should have a relatively large f0 difference, whereas HL speakers who do not pattern like Seoul speakers will not differentiate the two types of sounds through f0 (regardless of the actual pitches of each phonation type).

Indeed, the speakers of the G1 group, who correspond to those who immigrated to the USA at a later age, have greater f0-difference values than the speakers of the G2 group, while G1.5 speakers generally fall in the middle. For female speakers only were there significant effects of generational group ($F(2,19)=17.07$, $p<0.0001$) and age of immigration ($F(1,20)=18.39$, $p=0.0004$). Second-generation female speakers were clearly not following the first-generation females in producing a pitch contrast, and male speakers did not employ a pitch contrast as much as females almost all across the board, regardless of generation or age of immigration ($F(1,9)=0.161$, $p=0.698$). In fact, even the male speakers of the G1 group showed less of the pitch contrast than the female G1 speakers. Figure 5 illustrates

these findings.

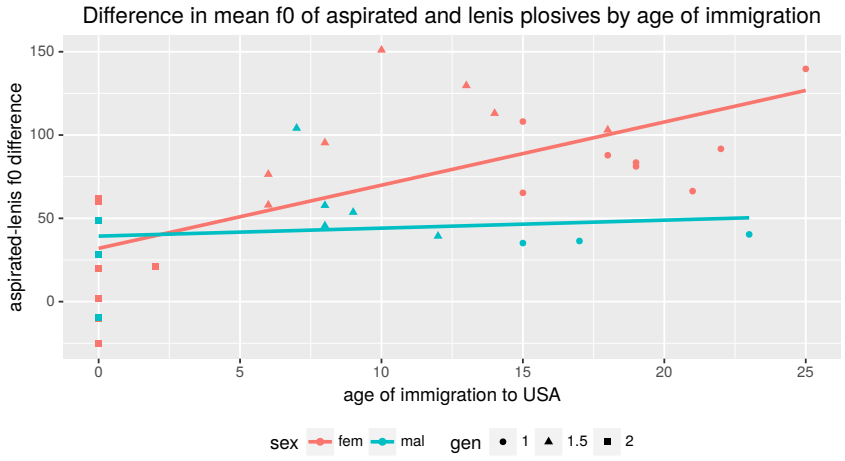

Figure 5: Fundamental frequency difference of word-initial aspirated and lenis stops and affricates by age of immigration to USA; a significant effect of age of immigration was found for females ($F(1,20)=18.39$, $p=0.0004$), but not for males.

These results suggest preliminarily that the speakers binned as G2, a proxy for second-generation Korean Americans, are indeed producing these consonants differently from the native speaker groups (G1 and G1.5, which are fairly similar to one another). The difference is much more significant for aspirated consonants than lenis consonants; the divergence is most clearly seen in the way female G2 speakers are not using pitch to differentiate aspirated consonants, and to a lesser degree in the way female G2 speakers produce both lenis and aspirated stops with higher VOT. This will be discussed more in Section 6.

4 Perception: Methods

In the second experiment, the voices collected in the first experiment were played back to listeners in order to see if any correlations could be found between speakers' acoustic characteristics (use of the VOT and f0 cues) or demographic information and listener perception of generation status or proficiency. For this experiment, the recordings of target words in contextualized sentences (see Appendix A) were used, including both Korean and English sentences.

10 Korean-identifying individuals (7 female, 3 male, average age 20.9) were recruited for the perception experiment and compensated monetarily for their participation. Among these participants, no speaking fluency in Korean was required, only prior exposure to the

Korean language from early childhood environment, and some were born and raised in locations other than California or Seoul.

Participants listened to the speech stimuli from the 'natural context' sentences recorded in the production experiment and then made judgments about social attributes of each speaker using Likert scales. The five scales were perceived proficiency, foreign or non-native accent[14], friendliness, current age, and age of arrival to the United States (see Appendix B). The order of appearance of the Likert scales and the order of speech stimuli were randomized.

In addition to the perception task, participants were asked to complete an in-depth language attitudes survey that elicited thoughts on their relationship with their Korean heritage and language use, detailed information about their prior language experience, and meta-linguistic judgments of "Korean-accented English"[15].

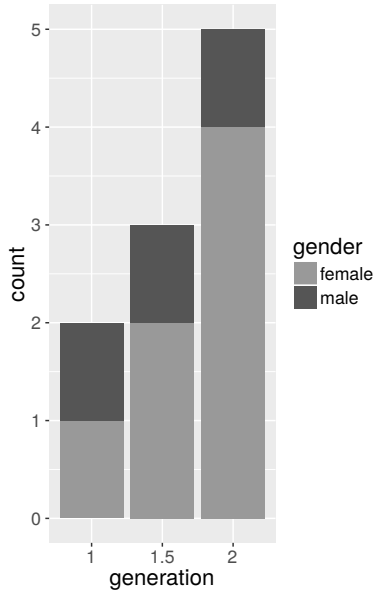

Figure 6: Participants in the perception experiment.

5 Perception: Results

The results of the perception study are a series of scores for each characteristic of each speaker. The mean perceptual score can be plotted against other scores (to visualize correlation between similar characteristics) or against actual speaker characteristics (to test listener discernment). For example, Figure 7 shows that perceived proficiency was highly negatively correlated with perceived non-native accent (e.g., the most proficient English speakers had the least amount of non-native accent). We can conclude that proficiency in either language was not seen as independent of the accent used when speaking it[16]. Henceforth "perceived proficiency" will be the primary variable used for judging speaker fluency.

[14] When listening to Korean stimuli, listeners judged each voice on its "American accent"; when listening to English stimuli from the same speakers, listeners judged each voice on its "foreign accent".

[15] Clearly, this amount of in-depth ethnographic work should have been performed for the participants in the production portion of this project, but as it is, I will be using the information given from the perception experiment participants as a kind of proxy for the communities of Korean immigrants and Korean Americans as a whole.

[16] This result is unsurprising given the nature of the perception stimuli: all the sentences were grammatical and identical from speaker to speaker within a block, so listeners were probably cuing into pronunciation, speech rate, and other accent-related variables when judging proficiency.

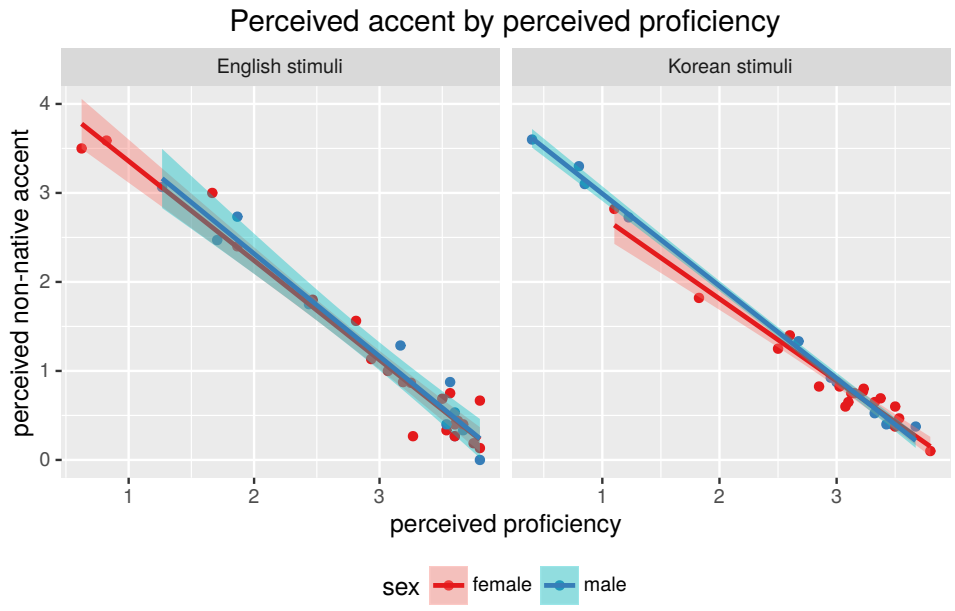

Figure 7: Perceived proficiency in English was significantly and strongly negatively correlated with perceived amount of non-native accent (R=-0.979, p<0.001). Perceived proficiency in Korean was similarly correlated with non-native accent (R=-0.0992, p<0.001).

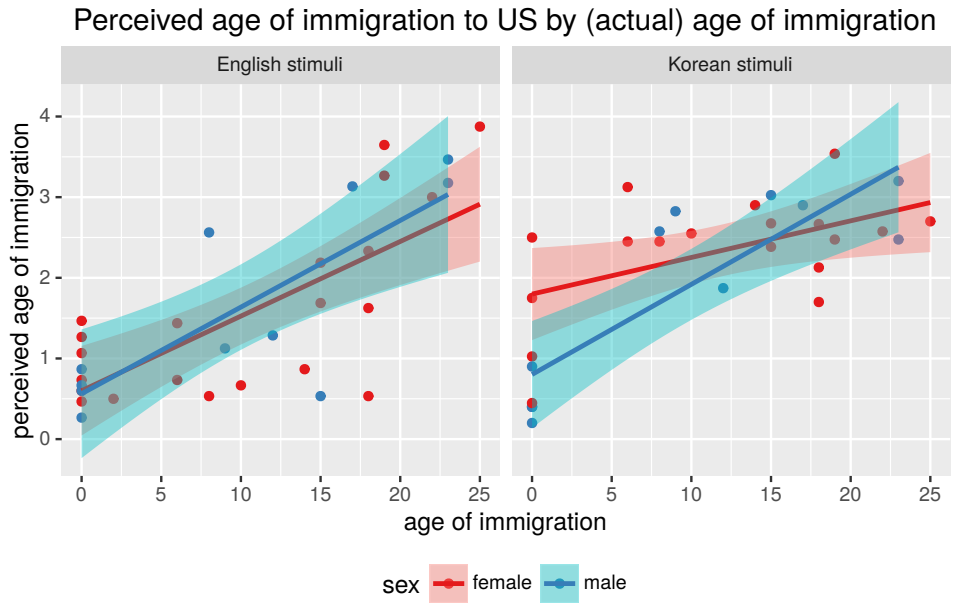

Figure 8: Speakers' perceived age of arrival and actual age of arrival were significantly positively correlated (with genders pooled: for Korean stimuli: R=0.681, p<0.001; for English stimuli: R=0.752, p<0.001).

To take another example, we can examine how accurate listeners were in an objective task: determining, from the voice stimuli, when a speaker immigrated to the United States. The question for this characteristic was phrased as, "Since when has this speaker lived in the United States?", with a ranking of 0 indicating a speaker who was born here, rankings of 1, 2, and 3 indicating speakers who had moved at subsequent points in childhood and adolescence, and a ranking of 4 indicating "just arrived".

When the average score for perceived age of immigration is plotted against the speakers' actual ages of immigration (where, again, 0 indicates a second-generation Korean American), a robust and significant correlation emerges. With an R-value of 0.681 (for the Korean stimuli), the correlation is not indisputable, however, and Figure 8 shows that there is a stronger correlation for male speakers than female speakers, and, importantly, that the fitted regression line for the female speakers is highly affected by two or three G2 speakers with quite low scores for perceived age of immigration. That is to say, if they were removed from the analysis as outliers, the result would be almost no correlation between perceived age of immigration and actual age of immigration.

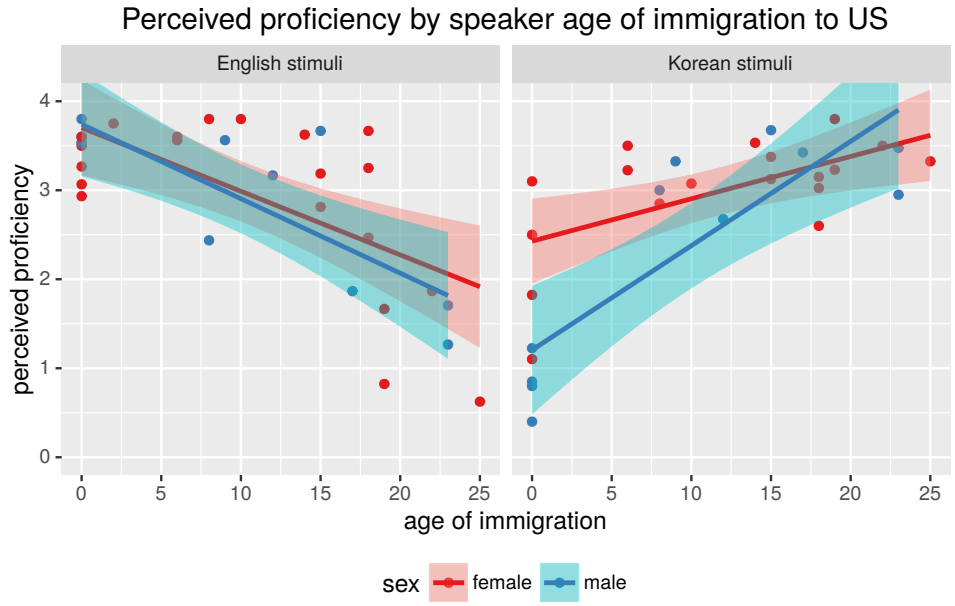

Figure 9: With genders pooled, speakers' perceived proficiency in Korean was positively correlated with their age of arrival (R=0.705, p<0.001); perceived proficiency in English was negatively correlated with their age of arrival (R=-0.702, p<0.001).

A similar pattern emerges when analyzing perception of proficiency from the Korean stimuli. As seen in Figure 9, greater proficiency in Korean is correlated with speakers who

were older when they immigrated to the United States. But once again, the four female speakers who were born in the United States (age of immigration = 0) find themselves rather dispersed on the scale of perceived proficiency. Taking out the two lowest scorers would considerably reduce the R-value of the measured correlation.

It stands to reason, therefore, that the female second-generation (G2) speakers differ widely from one another. As noted in Section 2, there were differences in speech rate due to lower reading proficiency of second-generation speakers. However, it is also possible that the use of the tonogenetic cues (less VOT contrast and more f0 contrast) maps onto perception of proficiency: specifically, if the second generation female speakers rated as more proficient were using the tonogenetic cues or not.

Table 5 lists the four female speakers in G2 whose recorded Korean stimuli were used in the perception task. It also lists their scores for perceived proficiency and differences in mean aspirated and mean lenis VOT and f0. Below that are the average measurements for each generational group, displayed for comparison.

subj	gen	immigration age	speak/read prof.	perc. prof.	mean asp-len VOT diff (sec)	mean asp-len f0 diff (Hz)
140	2	0	2/2	1.10	0.0120	61.65
105	2	0	2/3	1.83	0.0129	1.86
102	2	0	3/2	2.50	0.0174	-25.39
108	2	0	3/2	3.10	0.0019	60.2
avg	*2*	0	2.1/1.7	1.48	0.0122	19.68
avg	*1.5*	10	2.8/2.9	3.13	0.0078	85.59
avg	*1*	19	3/3	3.30	0.0052	75.96

Table 5: G2 speakers' self-rated Korean speaking and reading proficiency scores (scale of 1-3), perceived proficiency scores (scale of 0-4, Korean stimuli) and VOT and f0 measurements (aspirated-lenis differences), along with generation group averages.

As it turns out, there does not appear to be any correlation between proficiency and either of the acoustic measurements. Speakers 140 and 105 had the lowest proficiency ratings, but speaker 140 clearly differentiated aspirated and lenis stops by pitch (with an aspirated-lenis f0 difference of 61.65 Hz, closer to the range of native speakers). She did not, however, demonstrate the collapse in VOT contrast as evidenced by a small aspirated-lenis VOT difference, with a relatively large difference of 0.012 seconds. In comparison, speaker 108 had a very low aspirated-lenis VOT difference and a relatively high aspirated-lenis f0 difference, which corresponded to her high proficiency score.

This may indicate that listeners are cuing in to VOT and not to f0 when judging speakers on their proficiency. Recall that the male speakers in the study participated in the VOT merger to varying degrees depending on age of immigration, but did not have any discernible difference in amount of pitch contrast produced depending on age of immigration. These

same male speakers also had a very strong correlation between perceived proficiency and age of immigration, which may indicate that the VOT difference is being used by listeners as a cue to proficiency.

However, it must be noted that this is merely a depiction of a correlation, not a stance on causation. Furthermore, we recall that with the sentence-length stimuli that were read by the speakers, it is likely that confounding factors such as speech rate and reading fluency are at play.

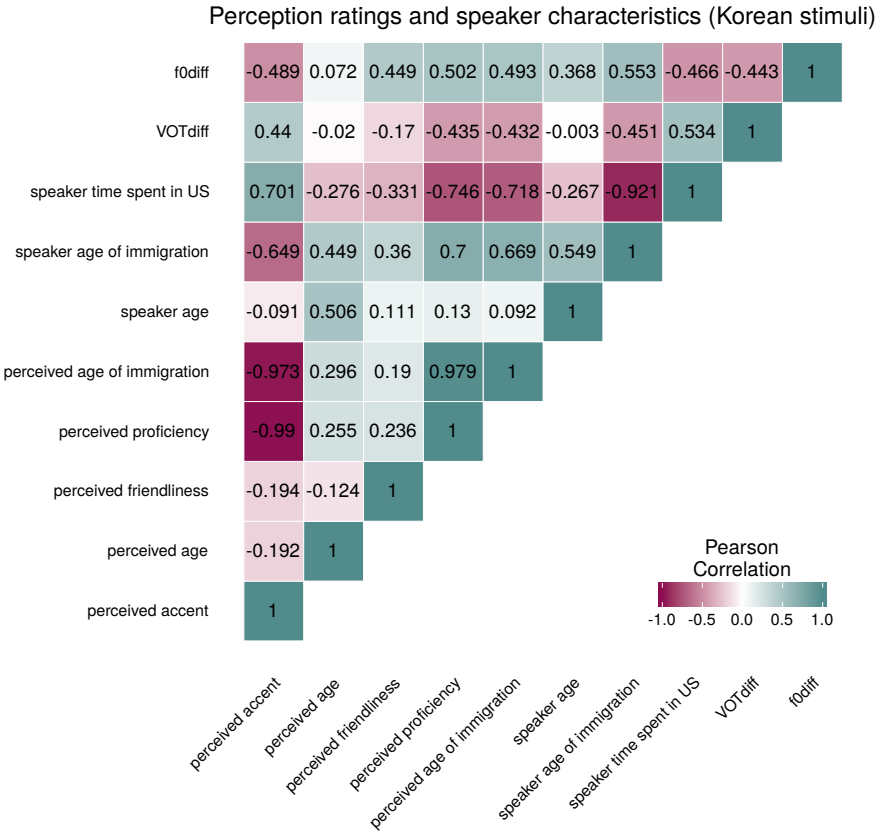

Figure 10: Correlation matrix of perception scores for the Korean stimuli and acoustic and demographic measurements of the speakers.

Pearson's correlation tests reveal that f0 and VOT are equally correlated to several factors, as can be seen in Figure 10. These are statistically significant positive and negative correlations, but the correlation strengths are not very high. Difference in aspirated-lenis f0, for example, is positively correlated with perceived proficiency (R=0.502, p=0.009) and perceived age of immigration (R=0.493, p=0.011), and also negatively correlated with

years spent in the United States[17] (R=-0.466, p=0.017). Difference in aspirated-lenis VOT is, predictably, correlated in the opposite direction with these same characteristics, with the strongest and most significant correlation being with years spent in the US (R=0.502, p=0.009).

Among the stronger correlations, however, we see that perceived proficiency is positively correlated with speaker age of immigration (R=0.705, p<0.001) and negatively correlated with amount of time spent in the US (R=-0.746, p<0.001).

Finally, the effect of the speakers' own ratings on Korean proficiency were compared to their perceived proficiency scores. Speakers in the production experiment rated themselves on a three-point scale on their speaking, listening, and reading fluency. Of course, speakers may have had different conceptions of what each point on the rating scale represented. Nevertheless, when genders were pooled, the subjects' perceived proficiency was found to be significantly influenced by their rating on all three scales (p<0.001 for speaking and reading, and p=0.002 for listening).

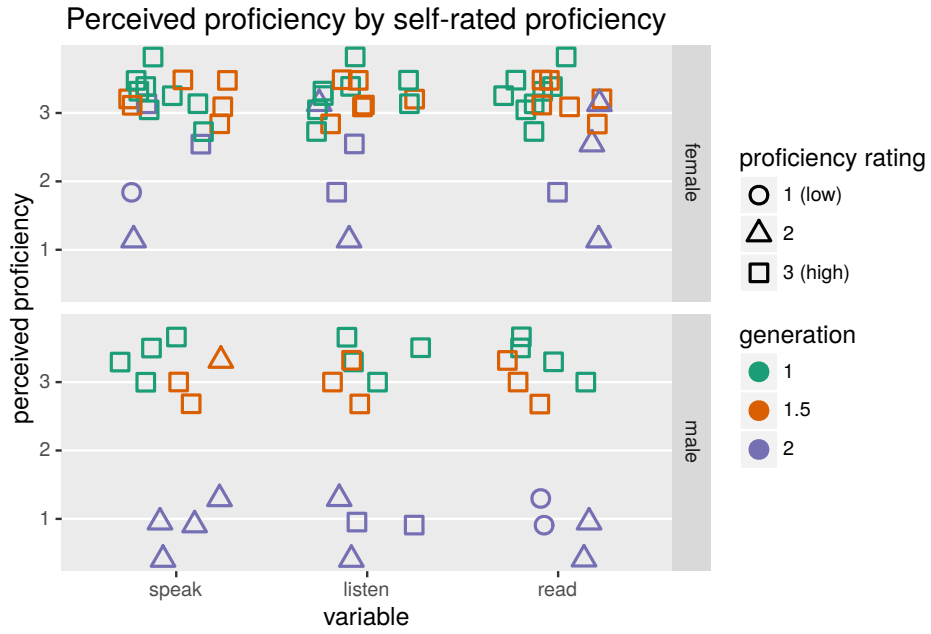

Figure 11: Perceived proficiency of speakers by self-reported speaking, listening, and reading proficiency, split by gender. When genders were pooled, ANOVA results showed significant effects of the rating on all three scales on perceived proficiency in Korean.

This demonstrates that speakers who rated themselves "1" or "2" on the scale were usually correspondingly perceived as being less proficient. Figure 11, which separates the genders,

[17] which is strongly but not perfectly negatively correlated with age of immigration

also illustrates how clearly separated the "proficient" speakers are from the "not proficient" speakers and how generational groups still from visible clusters in the proficiency data.

6 Discussion

"Korean is heavily connected to my Korean-American identity; if I weren't able to speak it, it would've been a very different experience." – G1.5 female, age 21

The production experiment showed that second-generation speakers are producing contrasts between lenis and aspirated stops differently from first-generation and 1.5-generation speakers. The primary difference is in the production of aspirated stops, which have a lower average f0 and higher average VOT, especially for female speakers. The VOT merger does not appear to have taken place in the second-generation group, which both confirms this study's hypothesis and corroborates the findings of (Kang and Nagy, 2016). There are a number of possible reasons for this.

Second-generation speakers may produce lenis and aspirated stops with higher VOT as a result of contact with English, which is one of the hypotheses put forth in Kang and Nagy (2016). English voiced and voiceless stops are primarily contrasted using VOT, which may influence Korean heritage speakers to also use VOT to distinguish between lenis and aspirated stops. In addition, Kang and Guion (2006) determined that English voiceless stops had slightly higher VOT than Korean aspirated and lenis stops (which were very similar as a result of the merger); thus, if Korean heritage speakers map Korean aspirated stops onto English voiceless stops, this could result in the higher VOTs for Korean aspirated stops. It would be evidence of a "mixed" phonological system for the two languages of these HL speakers. However, it must be noted that the same study (Kang and Guion, 2006) argued that early sequential bilinguals, who may also be the HL speakers with the highest speaking proficiency, maintained two distinct systems for both languages.

The maintenance of some contrast is important and not unprecedented. Babel (2009) found evidence of English influence in Northern Paiute subphonemic variation. The category boundaries of stops and fricatives in the younger speaker had shifted presumably due to decreased usage frequency and/or direct contact with English, but crucially, this did not cause a loss of contrast. Although Babel's study was of an indigenous American language and not an immigrant heritage language, the cases are parallel. In another case, Godson (2004) found evidence that English influence in the vowels of Western Armenian heritage speakers depended not just on the age at which speakers became English-dominant, but also on the vowels themselves: only those that had close parallels in English were affected. Phonetic attrition due to the influence of the ambient language is strong, but L2 phonology will never completely override the abstract phonological knowledge the speaker possesses of the L1/heritage language.

Now, for phonetic changes in the speech of Korean Americans in particular, if it turns out that aspirated and lenis VOT both increase in correlation with the number of years spent in the United States, that would be one "apparent-time change" indication that contact with English is influencing production of Korean sounds. A pertinent future study could also analyze group average VOTs for English voiceless stops[18].

On the other hand, to address the individual variation in these data would require going back to the subjects and inquiring after the nature of their HL input (Flege, 2007), which is unfortunately not within the scope of the original project. That said, it has been shown that for accent perception in Koreans specifically, amount of accent can be modeled as a correlation with age of arrival alone, even when other factors such as amount and quality of English input is corrected for (Flege et al., 1999; Flege, 2007). Therefore, when it comes to the production side of this project, it may also be the case that age of acquisition information for the HL speakers is enough to create a sufficient model. The data on individual participants' ages of acquisition for English and Korean are available and currently are undergoing analysis.

What we have been able to discern from the in-depth language attitudes survey given to the perception experiment participants is that there is not nearly as much contact as one may assume between the Seoul variety of Korean and the assumed "Californian" Korean American variety that may exist. Second-generation Korean Americans grow up as Americans with exposure to Korean language and culture coming in only through limited channels. The majority of input is through their parents' idiolects. Participant 211, a second-generation 23-year-old, describes his Korean experience as having overheard it "spoken between parents and amongst relatives at family gatherings", but rarely directed toward him. Another second-generation speaker, 19 years old, comments on having had "daily exposure" to Korean through her family and going to Korean restaurants, but she also grew up in majority White neighborhoods in the Midwest.

Korean Americans with high levels of exposure to Korean tended to be those from California, especially Southern California. Participant 209, a 1.5-generation female who immigrated from Seoul at the age of 6, expressed that "being in Koreatown made me get lots of exposure, daily," and also believes that being ethnically Korean has caused her to use the language often. On the other hand, participant 211 admits that "there is a very minimal relationship" between his Korean identity and his language use, which to him is a point of regret. Both of these participants lived in Southern California, but their experiences are quite different: one comfortably "bicultural", as Lee (2002) describes, and the other plainly not comfortable with their monocultural status.

Above all, the amount of contact with Seoul Korean, be it through news and entertainment media or phone calls and travels to the motherland, appears to be minimal. Heritage

[18]These data are, in fact, already available and are currently being analyzed.

speakers of Korean are producing Korean differently at least in part due to some amount of isolation from the changes that have been taking place in Seoul, in addition to close contact with English. If the tonogenetic sound change was carried across the Pacific with the earliest wave of first-generation Korean immigrants in the 1960s, we would have expected it to have been passed on from parent to child. We would especially expect the parents of the current study's participants to have passed down tonogenesis to their children, as they were almost all born between 1950 and 1973 in Seoul or Gyeonggi-do and immigrated to the US in adulthood (between 1980 and 2006). Yet despite the (speculative but likely) presence of the tonogenetic sound change in the parents' generation and a relatively high level of exposure to Korean in the children's generation, the heritage Korean speakers are not adopting it.

Additionally, it may be that there is a causative relationship between the lack of tonogenetic sound change in the speakers of this study and their membership in a younger age cohort when compared to past studies. The youngest subject in the Seoul corpus study (Kang, 2014) was born in 1984; in comparison, the oldest subject in the current study was born in 1986. However, one cannot conclude that all young speakers of Korean (whether heritage or native) are not participating in the change, since the current study found that young native speakers in the same age cohort as the heritage speakers closely matched those in the Seoul corpus study. Speaker age is an important consideration here, but the heritage speaker identity is still the clearest locus of difference [19].

As for the perception of these heritage speakers, it is reasonable to assume that the use of f0 and tradeoff with VOT are not what the perceivers are listening to. In fact, post-task interviews with the perception task participants revealed that most of them were cuing in on temporal characteristics (i.e., speech or articulation rate) when judging a speaker's likelihood of being first- or second-generation. This is, of course, their meta-linguistic judgment, and to bolster this hypothesis, the actual speech rate of the speech stimuli made will be measured. But in order to look at the tonogenetic cues specifically, a matched-guise speech perception test is being designed that will use the stimuli from the most proficient speakers of each generation group, albeit manipulated to have different VOT and f0 measurements. This targeted approach is more likely to give insight into how perceivers are using the VOT-f0 tradeoff than the correlations in Section 3 that only adumbrate a general picture.

[19] For another, closer comparison: the sample population in the Toronto study (Kang and Nagy, 2016) was born between 1926 and 1992 and recorded in 2009-2011, so the youngest Korean Canadian subjects in the Toronto study were of equivalent age to the average Korean Californian subject in this study.

7 Conclusion

This study finds that second-generation Korean Californians are not participating in the sound change present in the Seoul variety of Korean whereby VOT of word-initial lenis and aspirated stops is merging and f0 of the subsequent vowel is being used as the primary means of contrast.

Now, is there a Korean American (or Korean Californian) variety of Korean? In one sense, yes: there are measurable phonetic differences among generational groups. However, it is hard to pinpoint what the causal relationship may be, since many factors could explain these differences. It may not necessarily be a variety that marks bicultural identity; it could be a variety that results purely from language attrition or incomplete acquisition. This work is in progress and has not been able to prove very much definitively beyond what the raw data shows. Nevertheless, it is significant that young Korean Americans of the second generation are not participating (equally) in a major sound change that all of their age-specific counterparts in South Korea have completed. It is also clear from the perception experiment that the speech of Korean Americans in general is recognizable as being a heritage variety, or at least recognizable as not being the same as the speech of native Seoul Korean speakers regardless of fluency evaluations. Importantly, this does not hinge on the presence or absence of the tonogenetic sound change in the speaker's Korean consonants. With more data, stronger patterns may emerge.

Future work on this project will do two additional things: firstly, it will look at the other acoustic measurements of the speech data (speech rate, vowel duration, and spectral tilt, an indicator of creaky voice) and demographic information (reading fluency, parental biographical information) to look for other explanatory correlations that may exist. Secondly, it must take a deeper ethnographic dive into the lives and languages of Korean Americans and Korean heritage speakers, especially younger speakers as they acquire language and older speakers whose parents may have immigrated from Seoul before the sound change was complete (and so are for a different reason also likely not to have picked up the VOT-f0 tradeoff in their speech production).

In general, this study, in line with current phonetic and sociolinguistic work with HL speakers, is making a stronger case for applying new models of language acquisition, speech production, and identity formation to HL speakers, different than those used for bilingual speakers. It is hoped that heritage language studies, as well as linguistics and anthropology, will benefit from this new focus.

A Korean Perception Stimuli

The following eight sentences were used as stimuli in the perception task; four in each language. Some speakers did not make a usable recording of some sentences, in which case the recordings were discarded from the perception experiment. All transcriptions are in Korean Romanization, with the target word of each Korean sentence in boldface.

(1) Yojeumeun naeui **gani** apeuda
these-days I-POSS liver-NOM hurt
'My liver has been in pain these days.'

(2) Jihaceoleui **kani** jeongmal keuda
subway car-NOM very large
'The subway car is very large.'

(3) Oneuleun eojeboda **deol** cweossda
today-FOC yesterday-comp less cold-PST
'Today was less cold than yesterday.'

(4) Goyangi **teoli** neomu manhda
cat fur-NOM too many
'There is so much cat hair!'

(5) My best friend knows all about my past.

(6) She said that they flew here yesterday.

(7) I put on a hat when it's bright out.

(8) I don't know who had the bag.

B Korean Perception Rating Scales

The following text was presented to listeners for each Korean voice they heard. The order of questions for each voice was randomized.

Answer the following questions about the speaker.

- How proficient are they in Korean? (0=not proficient, 4=native-like)
- What would you guess is their age? (0=under 18, 1=18-21, 2=22-25, 3=26-29, 4=30 or over)
- How strong is their American accent? (0=no accent, 4=strong accent)
- How friendly are they? (0=unfriendly, 4=very friendly)
- Since when do you think they have lived in the US? (0=born here, 1=early childhood, 2=early teens (10+), 3=late teens (16+), 4=just arrived)

For the English stimuli, "Korean" was replaced with "English" and "American accent" was replaced with "foreign accent".

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