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A regressive transfer from L2 and L3 in L1 stop production*

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Oh, Mira. 2025. A regressive transfer from L2 and L3 in L1 stop production. *Linguistic Research* 42(1): 95-117. This study explores the influence of second and third languages on the production of stops in the first language of multilingual speakers. Korean(L1)/English(L2)/Japanese(L3) multilingual speakers (KEJ) and Japanese(L1)/English(L2)/Korean(L3) multilingual speakers (JEK) were divided into their proficiency levels in L2 and L3 to analyze the Voice Onset Time (VOT) of L1 stops they produce. For KEJ multilingual speakers, the VOTs of aspirated and lenis stops were shorter compared to Korean monolingual speakers when their Japanese(L3) proficiency was at the beginner level. Conversely, when both English(L2) and Japanese(L3) were at the advanced level, the VOTs of these stops were longer than Korean monolingual speakers. Furthermore, when their English(L2) proficiency was at the beginner level, the VOT of tense stops was lengthened. For JEK multilingual speakers, when English(L2) proficiency was advanced and Korean(L3) proficiency was at the beginner level, the VOTs of voiced and voiceless stops were longer compared to Japanese monolingual speakers. The present study demonstrates that not only the proficiency levels of L2 and L3 but also the typological proximity among languages determine how L2 or L3 influences the realization of L1 stops. The findings indicate that the dominant language of multilingual speakers, even their native language, is susceptible to the influence of foreign languages. **(Chonnam National University)**

Keywords L1 stops, multilingual speakers, Korean, Japanese, English, VOT, L2 and L3 proficiency levels, typological proximity

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1. Introduction

This study aims to explore the individual and combined effects of second (L2) and third (L3) languages on the production of native language (L1) stop consonants by multilingual speakers. It is widely recognized that language transfer occurs universally during foreign language acquisition.

Flege (1995) argued that phonetic transfer between languages is bidirectional. Not only does progressive transfer occur, where L1 influences the acquisition of L2, but regressive transfer is also possible, where L1 is affected by L2.

Bilingual speakers exhibit diverse patterns of influence between their L2 and L1 in terms of voice onset time (VOT). The VOT values differ across languages. For example, English voiceless stops have long VOTs, but Japanese and French voiceless stops have shorter VOTs than English voiceless stops. To be specific, the VOT values of /p, t, k/ in English are 87.2ms, 94.8ms, and 102.8ms, respectively, while the VOT values of /p, t, k/ in Japanese are 30.0ms, 28.5ms, and 56.7ms, respectively (Riney et al. 2007). Numerous studies have demonstrated that L1 affects the learning of L2 stops' VOT during L2 acquisition (Flege 1991). However, some studies have reported that L2 acquisition influences both the native language and L2 sound systems bidirectionally. For example, in Harada's (2007) study, the VOT values of /p, t, k/ in Japanese and English were measured for English-speaking children in a Japanese immersion program. The results showed that children in the immersion program pronounced Japanese voiceless stops with significantly longer VOTs compared to monolingual Japanese children, while pronouncing English voiceless stops with significantly shorter VOTs than English monolingual children. According to Fowler et al. (2008), French speakers who learned English at an early age had significantly longer VOT values for French stops compared to monolingual French speakers. Additionally, their VOT values for word-initial English stops were significantly shorter than those of monolingual English speakers. However, this does not mean they produced intermediate VOT values for both languages, as English VOT values were still notably longer than French VOT values. Major (1992) analyzed the L1 and L2 speech of five American English-speaking women who immigrated to Brazil at the age of 22 and lived there for over 12 years. The study found that their VOTs for English stop consonants were shorter than those of monolingual English speakers, while their VOTs for Portuguese stop consonants were longer than those of

monolingual Portuguese speakers.[1] Given that French and Portuguese voiceless stops have shorter VOTs than English voiceless stops, it can be concluded that L2 influenced the realization of L1 stops (LLama et al. 2010). These cases demonstrate bidirectional phonetic transfer between languages (Flege 1995).

Bilingual speakers also exhibit regressive transfer, producing L1 stop consonants with VOTs similar to those of L2 stops (Caramazza et al. 1973; Harada 2003; Flege 2005). For example, Flege (1987) found that bilingual speakers with French as L1 and advanced English as L2 produced French /t/ with longer VOTs compared to French monolinguals. Similarly, bilingual speakers with English as L1 and French as L2 produced English /t/ with shorter VOTs than English monolinguals.[2]

Flege's (1987) study focused on advanced L2 speakers to reveal the effects of L2 on L1 stop production. Similarly, Yoon (2015) demonstrated that adult Korean-English bilinguals' production of Korean stops was influenced by their advanced proficiency in English. These findings suggest that advanced proficiency in L2 affects L1 stop production. However, Chang (2010) and Yusa et al. (2010) argued that such effects could occur even at lower levels of L2 proficiency. Chang's study showed that within two weeks of learning Korean as an L2, English speakers exhibited significant changes in their native English VOT values due to the influence of Korean aspirated stops.

Most previous research on the regressive effects of foreign language acquisition on native language has focused on bilinguals acquiring only one foreign language. However, in modern society, multilingual individuals who speak more than two foreign languages are increasingly common (Braunmuller and Gabriel 2015). Therefore, it is necessary to investigate whether not only L2 but also L3 influences the realization of L1.

Most studies on third-language acquisition have focused on the progressive influence of L2 on L3 acquisition. For instance, the "L2 Effect Model" posits that

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1 Major's (1992) study suggests that higher proficiency in L2 increases the influence on L1 pronunciation. However, this influence was observed only in casual speech, not in formal speech, highlighting the need for further research into speech style differences.

2 Yoon (2015) investigated whether the L2 effect on L1 is related to the age of L2 learning. The study measured VOT and f0 of Korean stops produced by Korean-English bilingual children (8-13 years old) and adults who came to the US around age 18 and lived there for an average of 4 years and 4 months, currently over 21. Results showed that both bilingual children and adults produced longer VOTs for Korean aspirated and lenis stops compared to Korean monolinguals. Both groups also exhibited higher f0 for Korean lenis stops. Yoon (2015) argues that the influence of L2 English on L1 stop pronunciation is unrelated to the age of L2 acquisition.

the first foreign language has a greater influence than L1 when acquiring L3 (Williams and Hammarberg 1998; Bardel and Falk 2007; Wrembel 2010). For example, English(L1)/French(L2)/Spanish(L3) speakers produced Spanish voiceless stops with shorter VOTs under the influence of French(L2), while French(L1)/English(L2)/Spanish(L3) speakers produced Spanish voiceless stops with longer VOTs due to English(L2) (Llama and Cardoso 2018). Furthermore, third language acquisition literature on the L2 effect indicates that a beginner level of L3 proficiency tends to trigger greater L2 to L3 cross-linguistic influence given sufficient L2 proficiency (Hammarberg 2001; Gut 2010). Oh (2024) also investigated the L2 effect by analyzing the productions of L3 stops produced by Korean(L1)/English(L2)/Japanese(L3) speakers (hereafter referred to as KEJ) and Japanese(L1)/English(L2)/Korean(L3) speakers (hereafter referred to as JEK). The study found that both JEK and KEJ multilingual speakers exhibit the L2 effect when their English(L2) is advanced. JEK speakers produced native-like Korean(L3) aspirated stops when they are advanced L2 speakers, while KEJ speakers produced native-like voiced and voiceless stops in Japanese(L3) in terms of VOT when their L2 and L3 are both advanced. The study attributes the disparities between JEK and KEJ multilingual speakers regarding the role of L3 proficiency in the L2 effect to the typological proximity between L1 and L2. These findings suggest that multilingual individuals who have already experienced differences between their L1 and L2 phonetic systems are influenced by their L2 when acquiring L3.[3]

In L3 acquisition, the regressive transfer can also occur among the three languages (Freundlich 2016). Just as L2 influences the VOT of L1 stops in bilingual speakers as demonstrated in Harada's (2003) study, L2 can affect the realization of L1 stops in multilingual speakers. Polish voiceless stops have short VOT values (20-30 ms, short lag), while English voiceless stops have long VOT values (60-80 ms, long lag) (Lisker and Abramson 1964; Caramazza et al. 1973; Keating et al. 1981). Wrembel's (2011) research revealed that Polish(L1)/English(L2)/French(L3) multilinguals produced Polish /t/ and /k/ with significantly longer VOTs due to their advanced proficiency in English(L2).

Most previous studies on L1 stop production by multilingual speakers have several limitations. First, they primarily studied voiceless stops in phonologically voicing

3 In third language acquisition, not only L2 but also L1 exerts an influence (Williams and Hammarberg 1998; Oh 2024).

languages, which have a two-way contrast between voiced and voiceless stops, such as English, French, and Spanish. Second, they did not consider balanced proficiency in L2 and L3. Third, they did not sufficiently investigate the influence of L3 on L1 production.

This study investigates whether multilingual speakers' L2 and L3 influence their L1 stop production by analyzing two groups: KEJ and JEK multilingual speakers. By examining L1 stop production of these groups across varying levels of proficiency in their L2 and L3, this study seeks to answer three questions: First, do the VOTs of L1 stops in multilingual speakers differ from those of L1 monolingual speakers? Second, do the proficiency levels of L2 and L3 affect the realization of L1 stops? Third, does the typological similarity/difference among multiple languages influence the realization of L1 stops' VOTs? The reasons for targeting KEJ and JEK multilingual speakers are as follows. Korean stops have a three-way contrast: aspirated, lenis, and tense, while English and Japanese stops have a two-way contrast: voiceless and voiced. However, Korean and English stops have long-lag VOT, while Japanese has short-lag VOT. For these reasons, we believe that the typological differences between these multiple languages are suitable for studying how L2 and L3 influence the production of L1 stops. Oh (2024) studied the influence of L2 effects and typological similarity between languages on L3 stop production by KEJ and JEK multilinguals. In contrast, this study aims to explore how multilingual speakers' L1 stop production is affected by L2 and L3 proficiency levels and typological proximity between languages.

This paper is organized as follows: Section 2 presents the methods and results of an experiment on the production of L1 stops by KEJ and JEK multilingual speakers. Section 3 discusses the results of the phonetic experiment in light of topics concerning phonological acquisition in multilingual speakers. Section 4 summarizes the study and provides conclusions.

2. Production experiments on L1 stops by KEJ and JEK multilingual speakers

2.1 Experimental methods

2.1.1 Participants

Multilingual speakers who use Korean(L1), English(L2), and Japanese(L3) (KEJ) and those who use Japanese(L1), English(L2), and Korean(L3) (JEK) participated in this study. The production of L1 stops by KEJ and JEK speakers was compared to that of Korean monolingual speakers(KM) and Japanese monolingual speakers(JM), respectively. The participants in this study were the same individuals who participated in Oh's (2024) study. As outlined in Oh (2024), the proficiency levels of multilingual speakers in their L2 and L3 were assessed by having 10 native speakers of each language evaluate how closely the participants' pronunciation resembled native pronunciation. Ratings were assigned on a 7-point scale, and the average scores were used to classify learners. Participants with an average score of 3 or below were categorized as beginners, while those scoring 5.5 or above were classified as advanced speakers. The Korean speakers were from Gwangju in South Jeolla Province, the native English speakers were from the Midwest region of the United States, and the Japanese speakers were from Tokyo.[4] The multilingual speakers were categorized based on their proficiency levels in L2 and L3, and their participant demographics are reported in Table 1.

4 Lee and Oh (2016) report that VOT values of Korean stops are similar between Seoul and Gwangju speakers.

Table 1. Participant information

Speaker	L2 proficiency	L3 proficiency	Gender	Number of subjects	Average age(years)
Korean monolingual(KM)	NA	NA	F	4	29
English monolingual(EM)	NA	NA	F	6	26.5
Japanese monolingual(JM)	NA	NA	F	4	27.2
Korean(L1)/English(L2)/ Japanese(L3)	Beginner	Beginner	F	4	28.8
		Advanced	F	3	29.2
	Advanced	Beginner	F	4	34.2
		Advanced	F	3	28.2
Japanese(L1)/English(L2)/ Korean(L3)	Beginner	Beginner	F	4	34.2
		Advanced	F	4	31.2
	Advanced	Beginner	F	4	29.2
		Advanced	F	4	39.3

2.1.2 Data collection and processing

Monolingual speakers produced words from their respective native languages, while multilingual speakers produced words from all three languages. Word lists containing stop-initial words in Korean, English, and Japanese are shown in Table 2.

Table 2. Stimuli for production experiments

Language	Stimuli words	Carrier sentence	Phonemes
Korean	갈, 칼, 깔, 발, 팔, 빨, 달, 탈, 딸 /kal, k^hal, k'al, pal, p^hal, p'al, tal, t^hal, t'al/	이것도 _____이다. /ikʌt'o _____ita/ 'This is also ____.'	lenis: p, t, k asp: p^h, t^h, k^h tense: p', t', k'
English	pot, tot, cot, bot, dot, got	Say _____, too.	voiced: b, d, g voiceless: p, t, k
Japanese	パリ, タリ, カリ, バリ, ダリ, ガリ /pari, tari, kari, bari, dari, gari/	これも_____だよ. /koremo____dayo/ 'This is also ____.'	voiced: b, d, g voiceless: p, t, k

Recordings were done in a sound-attenuated room. Participants were instructed to read the sentences on the monitor of the computer in front of them at a comfortable speaking rate. The stimuli were presented using the Alvin software, and productions were digitally recorded as WAV files with a sampling frequency of 48kHz.

Participants produced 918 Korean tokens (9 words × 3 repetitions × 34 speakers),

648 English tokens (6 words × 3 repetitions × 36 speakers), and 612 Japanese tokens (6 words × 3 repetitions × 34 speakers). Among them, a total of 486 Korean words (9 words × 3 repetitions × 18 participants) and 360 Japanese words (6 words × 3 repetitions × 20 participants) were analyzed using the acoustic analysis program Praat 6.1.40 to segment the VOT intervals of stops in each language. The VOT was measured from the burst onset to the start of the following vowel's voicing, as determined by the waveform and spectrogram (Lisker and Abramson 1964). Measurement was done using VoiceSauce(v1.08) (Shue et al. 2011). Negative VOT values caused by voicing during the stop closure were excluded from analysis following Kang and Guion (2006). Statistical analysis was conducted using the lme4 package in R, with Tukey post-hoc tests applied for detailed comparisons.

2.2 Experimental results

The VOT results for L1 stops produced by multilingual speakers are presented in Tables 3 and 4. Table 3 shows the VOT values of Korean stop consonants according to the L2 and L3 proficiency levels of KEJ speakers.

Table 3. Korean(L1) stop VOT by KEJ multilingual speakers

L1	Japanese(L3) proficiency	English(L2) proficiency	Korean(L1) stops	VOT(ms)
Korean monolingual (KM)	NA	NA	lenis	79.44
			aspirated	82.59
			tense	13.22
Korean	Beginner	Beginner	lenis	52.59
			aspirated	69.76
			tense	21.89
		Advanced	lenis	63.45
			aspirated	76.45
			tense	14.93
	Advanced	Beginner	lenis	83.34
			aspirated	84.24
			tense	21.68
		Advanced	lenis	96.24
			aspirated	95.32
			tense	12.76

The VOT values of Japanese stop consonants according to the L2 and L3 levels of JEK speakers are presented in Table 4.

Table 4. Japanese(L1) stop VOT by JEK multilingual speakers

L1	Korean(L3) proficiency	English(L2) proficiency	Japanese(L1) stops	VOT(ms)
Japanese monolingual(JM)	NA	NA	voiceless	35.83
			voiced	12.79
Japanese	Beginner	Beginner	voiceless	39.67
			voiced	15.05
		Advanced	voiceless	49.81
			voiced	20.34
	Advanced	Beginner	voiceless	36.38
			voiced	11.91
		Advanced	voiceless	26.72
			voiced	11.15

2.2.1 Korean(L1) stop VOT by KEJ multilingual speakers

Figure 1 shows the VOT for lenis, aspirated, and tense stops in Korean(L1) by KEJ multilingual speakers, whose native language is Korean.

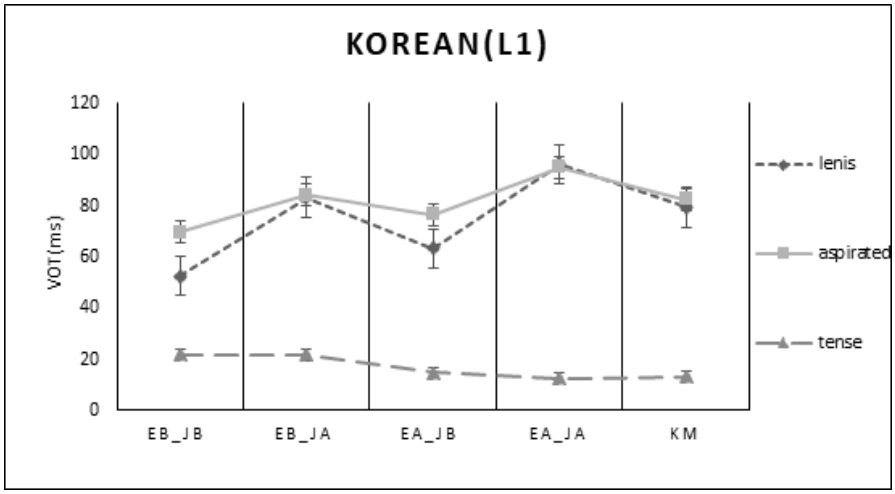

Figure 1. The VOT of Korean stops by KEJ multilingual speakers and Korean monolingual speakers (EA: English advanced; EB: English beginner; JA: Japanese advanced; JB: Japanese beginner; KM: Korean Monolingual)

The results of the statistical analysis, using linear mixed-effects models, are shown in Table 5. In this model, stop type (lenis, aspirated, tense), L2 proficiency, L3 proficiency, and their interactions were fixed effects, while individual participants were treated as random effects.

Table 5. Statistical results for VOT of Korean(L1) stops by KEJ multilingual speakers

Fixed effects:

	Estimate Std.	Error	df	t value	Pr(>|t|)
(Intercept)	94.826	7.235	13.223	13.108	0.000***
Stop Type	-82.067	3.706	403.124	-22.143	0.000***
L2 Proficiency	-10.265	9.576	13.253	-1.072	0.302
L3 Proficiency	-18.383	11.421	13.143	-1.609	0.131
Stop Type * L2 Proficiency	-14.406	5.216	403.115	-3.561	0.000***
Stop Type * L3 Proficiency	34.199	5.216	403.115	6.557	0.000***
Stop Type * L2 * L3 Proficiency	0.512	7.623	403.115	0.067	0.946

The results of the linear mixed-effects model analysis revealed that no significant correlation among stop types, L2 proficiency, and L3 proficiency could be found ($p>0.05$). However, the VOT values significantly differed by stop type ($p<0.001^{***}$), but L2 and L3 proficiency alone did not show significant effects. However, the interaction between stop type and proficiency levels in both L2 and L3 showed significant effects. The ANOVA analysis of lmerTest confirmed the need for a comparative analysis between groups. Post-hoc Tukey tests were conducted to compare group differences in VOT values and the results of Tukey's post hoc test are presented in Table 6.

Table 6. Post-hoc analysis of VOT for Korean(L1) stops (EA: English advanced; EB: English beginner; JA: Japanese advanced; JB: Japanese beginner; KM: Korean monolingual)

stops	L2 and L3 proficiency	*p*-value
lenis	KM vs. L2EB-L3JB	0.000***
	KM vs. L2EB-L3JA	0.741
	KM vs. L2EA-L3JB	0.049*
	KM vs. L2EA-L3JA	0.015*
aspirated	KM vs. L2EB-L3JB	0.026*
	KM vs. L2EB-L3JA	0.930
	KM vs. L2EA-L3JB	0.056
	KM vs. L2EA-L3JA	0.010**
tense	KM vs. L2EB-L3JB	0.000***
	KM vs. L2EB-L3JA	0.000***
	KM vs. L2EA-L3JB	0.462
	KM vs. L2EA-L3JA	0.932

KEJ multilingual speakers learned English as their L2 and Japanese as their L3. Thus, their realization of L1 stops can be influenced by both L2 and L3. If L3 influences the production of L1 stops, we can expect the VOT of Korean lenis and aspirated stops to shorten due to the inherently short VOT of Japanese voiceless stops. Conversely, if L2 exerts an influence, the longer VOT of English voiceless stops may cause the VOT of Korean stops to lengthen.

The examination of Table 3 reveals that the VOTs of lenis (79.44ms) and aspirated

(82.3ms) stops for KM are similar.[5] For KEJ multilingual speakers, when L3 proficiency is beginner and L2 proficiency is advanced, the VOT of Korean lenis stops is 63.45ms, which is significantly shorter than that of KM ($p<0.05^{*}$). Similarly, when both L3 and L2 are at beginner levels, the VOT of lenis stops is 52.59ms, significantly shorter than that of KM (79.44 ms) ($p<0.001^{***}$). This indicates that when L3 is at a beginner level, regardless of L2 proficiency, L3 influences the shortening of Korean lenis stop VOTs. However, when both L3 and L2 are advanced, KEJ multilingual speakers produce lenis stop VOTs at 96.24ms, significantly longer than those of KM (79.44ms) ($p<0.05^{*}$).

For Korean aspirated stops produced by KEJ multilingual speakers, when L3 and L2 are both at beginner levels, the aspirated stop VOT is 69.76ms, significantly shorter than that of KM (82.3ms) ($p<0.05^{*}$). When L3 is beginner and L2 is advanced, the aspirated stop VOT is 76.45ms which is shorter than that of KM but approaching statistical significance ($p=0.056$). However, when both L3 and L2 are advanced, KEJ multilingual speakers produce aspirated stop VOTs at 95.32ms, significantly longer than those of KM (82.3ms) ($p<0.01^{**}$). To summarize the results of VOTs for lenis and aspirated stops, when L3 proficiency is beginner, the VOTs of both lenis and aspirated stops in Korean are shortened due to L3 influence, regardless of L2 proficiency. Conversely, when both L2 and L3 are advanced, the VOTs are lengthened due to L2 influence.

For tense stops in KEJ multilingual speakers, when both L2 and L3 are at beginner levels, the tense stop VOT is 21.89ms which is significantly longer than that of KM (13.22ms) ($p<0.001^{***}$). Similarly, when L3 is advanced and L2 is beginner, the tense stop VOT remains significantly longer at 21.68ms compared to KM ($p<0.001^{***}$). This suggests that for tense stops in Korean, regardless of L3 proficiency level, a beginner-level English influences the lengthening of VOTs.

The results of the VOTs by KEJ multilingual speakers reveal two findings. Firstly, the effects of L2 and L3 differ depending on the type of L1 stop consonants.[6] For

5 The VOT of Korean lenis stops has lengthened, while that of aspirated stops has shortened, making it impossible to distinguish the laryngeal contrast based solely on VOT. Consequently, f0 serves as the primary acoustic cue for distinguishing between aspirated and lenis stops, with VOT functioning as a secondary acoustic cue (Silva 2006; Kang and Guion 2008; Lee and Jongman 2018).

6 When perceiving Korean stop consonants, aspirated and lenis stops are correlated with VOT and f0 (fundamental frequency). However, tense stops are identified as tense based on their short VOT, regardless of changes in f0. This indicates that aspirated, lenis, and tense stops are sensitive to different

lenis and aspirated stops in Korean, L3 exerts an influence by shortening their VOTs when L3 proficiency was at the beginner level, regardless of L2 proficiency. However, when both L2 and L3 were at advanced levels, the VOT of lenis and aspirated stops became longer due to L2 influence. For tense stops in Korean, only L2 influences their realization by lengthening their already short VOTs when L2 was at the beginner level, irrespective of L3 proficiency. That is, KEJ multilingual speakers showed different patterns of influence from L2 and L3 depending on the stop type. For lenis and aspirated stops, L3 had a dominant influence when its proficiency was low, while L2 played a greater role when both L2 and L3 were at advanced levels. For tense stops, however, the influence primarily came from L2, even when its proficiency was low.[7] Secondly, the influence of L2 on L1 stop VOT does not consistently depend on whether L2 proficiency is advanced or beginner level. While most previous studies suggest that L2 effects predominantly occur in advanced speakers (Wrembel 2011), this study shows that for KEJ multilingual speakers the VOTs for lenis and aspirated stops lengthen when English proficiency is advanced but the VOTs for tense stops lengthen even when English proficiency is beginner. These results highlight how different types of stop consonants respond variably to influences from multiple languages in multilingual contexts. They also challenge prior assumptions that only advanced-level foreign language learners exhibit regressive transfer effects on their native language phonology.

2.2.2 Japanese(L1) stop VOT by JEK multilingual speakers

The VOT of Japanese(L1) stops produced by JEK multilingual speakers is illustrated in Figure 2.

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acoustic cues (Kim 2004).

7 This distinction may arise because tense stop VOTs are already short; thus, they cannot be further shortened by Japanese(L3) but can be lengthened by English(L2).

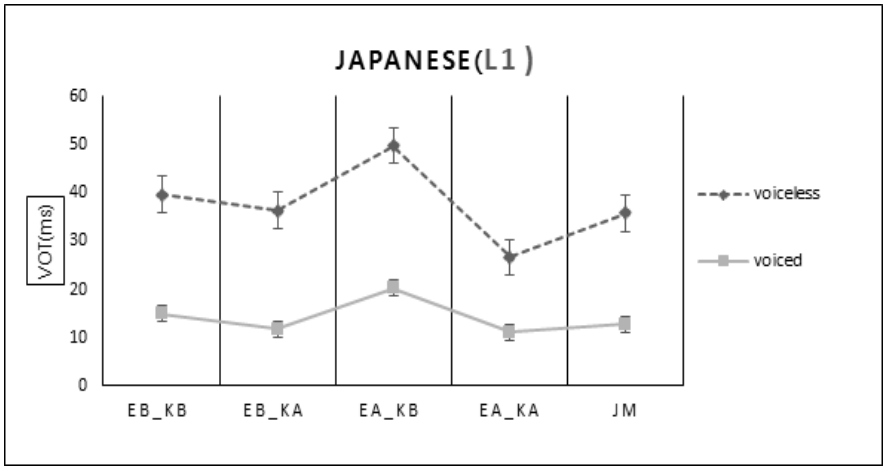

Figure 2. The VOT of Japanese stops by JEK multilingual speakers and Japanese monolingual speakers (EA: English advanced; EB: English beginner; KA: Korean advanced; KB: Korean beginner; JM: Japanese Monolingual)

Table 7 shows the results of the statistical analysis with VOT of Japanese stops as the dependent variable, stop type (voiced, voiceless) and L2 and L3 proficiency as fixed effects, and the interaction of stop type and proficiency as a random effect.

Table 7. Statistical results for VOT of Japanese(L1) stops by JEK multilingual speakers (EA: English Advanced; EB: English Beginner; KA: Korean Advanced; KB: Korean Beginner; JM: Japanese Monolingual)

Fixed effects:

	Estimate Std.	Error	df	t value	Pr(>|t|)
(Intercept)	11.146	8.835	13.181	1.262	0.229
Stop Type	15.578	5.201	267.000	2.995	0.003**
L2 Proficiency	0.768	11.406	13.181	0.067	0.947
L3 Proficiency	9.198	10.821	13.181	0.850	0.410
Stop Type * L2 Proficiency	8.887	6.715	267.000	0.323	0.086
Stop Type * L3 Proficiency	13.889	6.370	267.000	2.180	0.030*
Stop Type * L2 * L3 Proficiency	0.218	9.786	267.000	0.492	0.623

The results of the linear mixed-effects model analysis revealed that no significant correlation among stop types, L2 proficiency, and L3 proficiency could be found ($p>0.05$). However, VOT showed significant differences depending on the type of stops ($p<0.01^{**}$). There was no significant difference in VOT depending on L2 and L3 proficiency, but the correlation analysis results between stop type and L3 proficiency showed a significant correlation ($p<0.05^{*}$). As a result of the ANOVA analysis of lmerTest on the VOT of each speaker's Japanese stop consonants, it was confirmed that a comparative analysis between groups was necessary, and an intergroup comparison was conducted on the VOT of Japanese stop consonants. The results of Tukey's post hoc test on the VOT of stops between groups are presented in Table 8.

Table 8. Post-hoc analysis of VOT for Japanese(L1) stops (EA: English Advanced; EB: English Beginner; KA: Korean Advanced; KB: Korean Beginner; JM: Japanese Monolingual)

stops	L2 and L3 proficiency	*p*-value
voiceless	JM vs. L2EB-L3KB	0.793
	JM vs. L2EB-L3KA	0.995
	JM vs. L2EA-L3KB	0.037*
	JM vs. L2EA-L3KA	0.381
voiced	JM vs. L2EB-L3KB	0.223
	JM vs. L2EB-L3KA	0.795
	JM vs. L2EA-L3KB	0.027*
	JM vs. L2EA-L3KA	0.886

When JEK Multilingual speakers' L2 is advanced and L3 is beginner, their L1 voiceless stop VOT (49.81ms) was significantly longer than that of JM (35.83ms) ($p<0.05^{*}$). The VOT of voiced stops (20.34ms) was also significantly longer than that of JM (12.79ms) ($p<0.05^{*}$). This can be seen as the influence of acquiring English stops with longer VOT when L2 proficiency is advanced. The remaining groups of JEK speakers show VOT values similar to those of JM. It is notable that for JEK speakers, the L2 effect appears to be related to proficiency in both L2 and L3 since their L1 voiceless and voiced stop VOTs were longer than those of JM only when their L2 is advanced and L3 is beginner.

To summarize, the VOT of L1 stops by JEK multilingual speakers lengthens under the influence of English(L2) depending on the proficiency levels of L2 and L3.

3. Discussion

Comparing the VOTs of L1 stops produced by KEJ and JEK multilingual speakers reveals notable differences. JEK speakers exhibited the influence of English(L2) when their English proficiency was advanced, and their Korean(L3) proficiency was at the beginner level. This resulted in significantly longer VOTs for both voiced and voiceless stops in their native Japanese(L1). Conversely, KEJ speakers displayed the influence of English(L2) when both English(L2) and Japanese(L3) were at advanced levels, leading to lengthened VOTs for lenis and aspirated stops. However, when Japanese(L3) was at a beginner level, regardless of English(L2) proficiency, the VOT of Korean(L1) lenis and aspirated stops shortened due to the influence of Japanese(L3).

These differences in the influence of L2 and L3 on L1 VOT between JEK and KEJ speakers can be attributed to typological differences among the languages involved. For JEK speakers, where Japanese(L1) and English(L2) belong to typologically distinct categories, the influence of English(L2) dominates, resulting in longer VOTs for both voiced and voiceless stops. In contrast, for KEJ speakers, where Korean(L1) and English(L2) are typologically similar, and Japanese(L3) is different, both L2 and L3 exert influence. This leads to varying effects on lenis and aspirated VOTs, which can either lengthen or shorten depending on the proficiency levels of L2 and L3.

Llama and Cardoso (2018) studied the VOT of stops in multilingual speakers whose L1 was French, L2 was English, and L3 was Spanish. The study found that when both L2 and L3 were at advanced levels, the VOT of French(L1) stops was lengthened under the influence of English(L2). This aligns with the findings of the present study, where the VOT of lenis and aspirated stops in Korean(L1) by KEJ multilingual speakers was lengthened when English(L2) was advanced and Japanese(L3) was also advanced. However, for JEK multilingual speakers, when English(L2) was advanced but Korean(L3) was at a beginner level, L2 influenced the VOT of voiced and voiceless stops in Japanese(L1), causing them to lengthen. The fact that both JEK and KEJ multilingual speakers showed an influence from L2 when it was at an advanced level supports the findings of Llama and Cardoso (2018). However, it can be argued that

the effect of L2 is correlated with the proficiency level of L3 depending on the typological differences between the languages. For KEJ multilingual speakers, when both English(L2) and Japanese(L3) were advanced, the VOT of lenis and aspirated stops in Korean(L1) lengthened. In contrast, for JEK multilingual speakers, when English(L2) was advanced but Korean(L3) was at a beginner level, the VOT of voiced and voiceless stops in Japanese(L1) lengthened. In other words, differences in the typology of stops among L1, L2, and L3 may result in varying manifestations of L2 influence. In Llama and Cardoso's (2018) study, L1 was French, L2 was English, and L3 was Spanish. The VOT of voiceless stops in English(L2) is long, while that in Spanish(L3) is short, indicating a typological difference between L2 and L3 stops. For KEJ multilingual speakers, since their L2 is English and their L3 is Japanese, there is a typological difference in VOT between these languages' stops, which aligns with the findings of Llama and Cardoso (2018). On the other hand, for JEK multilingual speakers, their L2 is English and their L3 is Korean; thus, there is no typological difference between their L2 and L3 stops. This suggests that differences in proficiency levels of L3 affecting the manifestation of L2 influence may be attributed to typological differences between a multilingual speaker's L2 and L3. However, further research is needed to examine cases involving multilingual speakers with a wider variety of language typologies.

It is difficult to find prior studies on multilingual speakers' speech production that reveal the influence of L3 on their L1. This study explored stops in KEJ multilingual speakers whose L1 is Korean, L2 is English, and L3 is Japanese as well as JEK multilingual speakers whose L1 is Japanese, L2 is English, and L3 is Korean. As a result, it became possible to compare the influence of L3 on their respective L1s. For KEJ multilingual speakers, regardless of their proficiency in English(L2), when Japanese(L3) was at a beginner level, the VOTs of lenis and aspirated stops shortened. Observing how Japanese(L3) influences lenis and aspirated stops for KEJ multilingual speakers suggests that when there is no typological difference between their L1 and L2 but there is a difference between their L2 and L3, an influence from their L3 on their L1 can emerge. However, for JEK multilingual speakers whose L1 is Japanese and whose L3 is Korean, when their English (L2) proficiency was advanced but their Korean (L3) proficiency was at a beginner level, the VOTs of voiced and voiceless plosives in Japanese(L1) lengthened. It remains unclear whether this can also be attributed to an influence from Korean(L3). This ambiguity arises because both

English(L2) and Korean(L3) realize stop VOTs with long durations; thus, the lengthening of VOTs in Japanese(L1) stops could also be interpreted as an effect from English(L2). Future research could examine cases where Japanese serves as the L1, while French serves as the L2 and Korean serves as the L3. If such a study finds that the VOTs of Japanese stops are longer than those produced by monolingual Japanese speakers, it could be concluded that this lengthening results from an influence by Korean(L3). Such research remains a task for future exploration.

This study demonstrated that the production of L1 stops is influenced regressively by L3, as evidenced by the shortened VOTs of lenis and aspirated stops produced by KEJ multilingual speakers when their Japanese(L3) was at a beginner level. Similarly, Oh's (2024) study found that JEK multilingual speakers produced shortened VOTs of lenis and aspirated stops when their English(L2) was at a beginner level. This suggests that the production of L3 stops is also influenced progressively by L1. In other words, in multilingual contexts, L3 exerts a regressive influence on the production of L1 stops, whereas L1 has a progressive effect on the production of L3 stops.

Korean tense and Japanese voiced stops have similarly short VOTs. However, the L2 effect manifests differently regarding L2 and L3 proficiency. The VOT of tense stops in Korean produced by KEJ speakers lengthens due to the influence of L2 when KEJ's English(L2) is at a beginner level, regardless of L3 proficiency. On the other hand, the VOT of voiced stops in Japanese produced by JEK speakers lengthens when English(L2) is advanced and Korean(L3) is at a beginner level. This difference reflects the complex interaction between each language's phonological system and the L2/L3 effects on L1 production. For Korean, the three-way contrast system (tense, lax, aspirated) may allow for VOT influence even in early stages of L2 English learning. In contrast, Japanese, with its two-way contrast system (voiced, voiceless), shows VOT changes when advanced L2 English proficiency combines with beginner-level L3 proficiency.

The findings in this study suggest that multilingual speakers' phonological systems interact in complex ways, and the influence of L2 and L3 on native language pronunciation varies depending on the proficiency levels in each language and typological differences among languages.

4. Conclusion

This study examined the influence of L2 and L3 foreign languages on the production of L1 stops of multilingual speakers. Korean(L1)/English(L2)/Japanese(L3) multilingual speakers and Japanese(L1)/English(L2)/Korean(L3) multilingual speakers were categorized according to their proficiency levels in L2 and L3, and the VOTs of their L1 stops were analyzed.

The first research question was whether the VOTs of L1 stops in multilingual speakers differ from those of L1 monolingual speakers. The results revealed that depending on L2 and L3 proficiency levels, the VOTs of aspirated and lenis stops in KEJ speakers were both longer and shorter compared to Korean monolinguals. Similarly, the VOTs of voiced and voiceless stops in JEK speakers were longer than those of Japanese monolinguals. These findings demonstrate that the VOTs of L1 stops in multilingual speakers can differ from those of monolinguals.

The second research question explored whether L2 or L3 proficiency affects the production of L1 stops. For KEJ speakers, the VOTs of aspirated and lenis stops were shorter than those of Korean monolinguals, when Japanese(L3) was at the beginner level, regardless of English(L2) proficiency. However, when both English(L2) and Japanese(L3) were at advanced levels, the VOTs of aspirated and lenis stops were longer. Moreover, the VOTs of tense stops were lengthened when English(L2) proficiency was at the beginner level, regardless of Japanese(L3) proficiency. For JEK speakers, when English(L2) proficiency was advanced and Korean(L3) proficiency was at the beginner level, the VOTs of voiced and voiceless stops were longer than those of Japanese monolinguals. These results indicate that L2 and L3 proficiency levels affect the realization of L1 stops.

The third research question investigated whether typological differences among L1, L2, and L3 influence the realization of L1 stop VOTs. KEJ speakers showed varying VOTs for Korean(L1) stops due to the combined influence of English(L2) and Japanese(L3). When both L2 and L3 were advanced, the influence of English(L2) lengthened the VOTs of aspirated and lenis stops. However, when Japanese(L3) proficiency was at the beginner level, regardless of English(L2) proficiency, the influence of Japanese(L3) shortened the VOTs of aspirated and lenis stops. In contrast, JEK speakers exhibited lengthened VOTs for Japanese(L1) voiced and voiceless stops primarily due to the influence of advanced English(L2), regardless of Korean(L3)

proficiency. This difference in L2 and L3 influence between KEJ and JEK speakers arises from the typological differences among L1, L2, and L3. For JEK speakers, Japanese(L1) and English(L2) are typologically distinct, leading to a dominant influence of English(L2) on L1 stops. In contrast, for KEJ speakers, where Korean(L1) and English(L2) share typological similarities, the distinct typology of Japanese(L3) results in both L2 and L3 affecting the realization of L1 stops.

This study demonstrates two aspects of L2 influence on Korean stops produced by KEJ multilingual speakers. First, when both L2 and L3 are advanced, English(L2) plays a role in lengthening the VOTs of aspirated and lenis stops. Second, when English(L2) proficiency is at the beginner level, it still lengthens the VOTs of tense stops, regardless of Japanese(L3) proficiency. This suggests that the influence of L2 on L1 depends on the interaction between stop types and L2 proficiency level.

Most previous studies on the influence of foreign languages on L1 have focused on bilingual speakers. However, this study explored the effects of L2 and L3 on L1 stop consonant production in multilingual speakers. Furthermore, this research presents results that contradict Mack's (1989) assertion that most multilingual speakers have a dominant language (Grosjean 1992) and that the dominant language is not influenced by non-dominant languages. In this respect, it will contribute to the future development of theories on language acquisition in multilingual speakers. Additionally, this study will enhance our understanding of the complexity of cross-linguistic transfer phenomena in the process of multilingual acquisition.

This study argued that the realization of native language stop consonants in multilingual speakers varies not only according to the proficiency levels of L2 and L3 but also based on the typological differences between each language. The current study focused on multilingual speakers using Korean(L1)/English(L2)/Japanese(L3) and Japanese(L1)/English(L2)/Korean(L3). However, future research should verify these findings by examining multilingual speakers with various typological proximity among their L1, L2, and L3.

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