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**Significance of VLT and VOT in the description of Stop Consonant:  
Case of Hindi and Korean p-t-k in Contrast**

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**Abstract**

*This is a study of Korean and Hindi stop consonants p, t, k in terms of VOT (Voice Onset Time) duration and VLT (Voice Lead Time). VOT durations were measured from word-initial and word-medial stop consonants from native speakers of Hindi, and Korean. In order to draw inferences for SLA (Second Language Acquisition) and pedagogical implications similar data is also recorded from five native speakers of Hindi who were learning Korean as a second language. So, three data sets, viz. L1 Hindi, L2 Korean, and L1 Korean are used.*

**Key words:** VOT, VLT, Second Language Acquisition, tense and lax vowels.

**1. Introduction**

This paper discusses the differences of the acoustic features of Voice-Lead Time (VLT) and Voice-Onset Time (VOT) in L1 and L2 Korean and L1 Hindi stop consonants by contrasting the three stop consonants. As cited in Port (1979:654) VOT plays a major role to distinguish initial voiced and voiceless (or lax and tense) stop in English as well as in numbers of other languages such as Hindi. Voiceless stop /p, t, k/ have positive VOT with voicing lagging after release burst, and the term aspiration is used to describe the auditory effect accompanying this voicing lag. On the other hand, voiced stop /b, d, g/ have either negative VOT (i.e. Voice Lead Time) or very short VOT. However, VOT duration depend not just on the voicing feature, but is also very sensitive to various other acoustic features.

Both Hindi and Korean stop consonants have their own unique acoustic properties. Hindi stop consonants have four-way contrasts which are Voiced Stop (VS) / Voiceless Stop (VLS) / Voiced Aspirated Stop (VAS) / Voiceless Aspirated Stop (VLAS), Korean stops have three-way contrasts which are Lax / Tense / Aspirated. According to the categorization, voicing feature is an important cue to characterize Hindi stop consonants, whereas there is no voiced stop consonant in Korean word-initial stop consonants. Therefore, when it comes to the contrastive analysis of the two languages, even if a stop sound of both languages seems to be similar, the actual acoustic feature may be different

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from each other. This qualitative difference may cause errors in Hindi speakers L2 Korean stop consonants. For example, Korean  $\text{ㅍ}/\text{p}/$  stop is pronounced as voiceless at word-initial position, and it also can be pronounced as voiced [b] when it is placed between vowels in word medial position, and it is also pronounced as a tensed sound [p'] when it comes at the syllable final position and at the same time it is not followed by an vowel or nasal consonant. In contrast, Hindi voiced stop consonants are always pronounced as voiced whether they occur at word initial or word medial positions. Because of this qualitative difference between two languages, Hindi speaking L2 Korean learners may face interference in their speech production. The paper studies how these different features of L1 Hindi stop consonants compare and contrast with L1 Korean stop consonants and may also lead to transfer to L2 Korean stop consonants in terms of  $\pm$  VOT.

One of explanations dealing with linguistic transfer is contrastive analysis hypothesis. It is a comparative study which is to research the differences or similarities between two or more languages, and is a useful method for 2<sup>nd</sup> language education. Although contrastive analysis hypothesis faces criticism, it is still valid in analysis of some linguistic aspect especially it is a valuable method to describe the cause of errors in phonetics and phonology (Dulay et al. 1982). According to Selinker (1992), language transfer is a very wide concept of inter and intra lingual influence, and the consensus view of language transfer is not an 'all or nothing' phenomenon. So, various approaches have been used to explain it so far. Despite the commonly recognized criticism, contrastive analysis is important as a preliminary step to understanding the range of similarities and differences across languages and subsequently for the purpose of language pedagogy one may formulate hypothesis of language transfer from one linguistic structure to another. This is because syntactic, lexical, grammatical and semantic interference show far more variation among L2 learners according to the learners' linguistic background. The articulatory interference shows relatively less variation, as the articulatory interference refers to the negative transfer which is the fossilized articulation habit of native language to the target language. There may be two reasons why learners pronounce a target language incorrectly like the style of native language. The first is the case of not recognizing the sound properly. This occurs when the phonological system of the native language is fixed in the mind in such a way that the new sound patterns are perceived only through a filter of native phonological patterns this leads to negative transfer to the target language. Second, even though the recognition for target language is proper, the pronunciation errors are made regardless of the intention, due to the articulation habit which is accustomed to the native language. These phenomena can be studied through contrastive analysis

## **2. Methodology**

The data for this study was collected from 10 female participants, all in their twenties; 5 Korean native speakers who are raised in Seoul or Gyeonggi-do (near capital region) and 5 Hindi native speakers who are learning Korean as a foreign language in B.A 3<sup>rd</sup> years at Jawaharlal Nehru University and had been raised in Bihar where Hindi is spoken as a native language.

There are two sets of stimuli of meaningful word-lists which are including 9 word-initial Korean stop consonants /p, p', p<sup>h</sup>, t, t', t<sup>h</sup>, k, k', k<sup>h</sup>/ for L1 and L2 contrast; and also corresponding 9 word-initial Hindi stop-consonants /b, p', p<sup>h</sup>, d, t', t<sup>h</sup>, g, k', k<sup>h</sup>/ for the contrast of L1s, with adjoining three vowels of /a, i, u/, and also Korean Lax alveolar stop /t/ at word-medial position with adjoining three vowels of /a, i, u/ is contrasted and analyzed.

All the words are provided randomly and the participants are asked to speak all the words three times.

Word List:

**Table 1: Word sample of Korean stop consonant**

Classification	f.v.	Bilabial	Alveolar	Velar
Lax	a	바다/pada/	다리 /tari/	가다/kada/
	i	비비다/pibida/	디디다/tidida/	기기 /kigi/
	u	부부 /pubu/	두다/tuda/	구두 /kudu/
Tense	a	빠지다 /p'adzida/	따다/t'ada/	까다 /k'ada/
	i	삐딱/p'it'ak/	띠톱/t'itop/	끼니 /k'ini/
	u	뿌리다/p'urida/	뚜벅/t'ubək/	꾸벅/k'ubək/
Aspirated	a	파다/p <sup>h</sup> ada/	타다 /t <sup>h</sup> ada/	카랑카랑 /k <sup>h</sup> araŋk <sup>h</sup> a raŋ/
	i	피부/p <sup>h</sup> ibu/	티눈 /t <sup>h</sup> inun/	키다리 /k <sup>h</sup> idari/
	u	푸다 /p <sup>h</sup> uda/	투입 /t <sup>h</sup> uip/	쿠리다 /k <sup>h</sup> urida/

**Table 2: Word sample of Hindi stop consonant**

Classification	f.v.	Bilabial	Alveolar	Velar
Voiceless Unaspirated	a	पपीता /papitā/	तकलीफ़ /taklif/	कपड़ा /kaprā/
	i	पिता /pitā/	तितली /titlī/	किताब /kitāb/
	u	पुराना /purānā/	तुरंत /turant/	कुमार /kumār/
Voiceless Aspirated	a	फफकना /phaphakn ā/	थकान /thakan/	खजूर /khajūr/
	i	फिसलना /phisalnā/	थिरकना /thiraknā/	खिचड़ी /khiçṛī/
	u	फुदकना /phudaknā/	थुकाना /thukānā/	खुदना /khudnā/
Voiced Unaspirated	a	बरसात /barsāt/	दबाना /dabānā/	गगन /gagan/
	i	बिना /binā/	दिमाग /dimāg/	गिनती /gintī/
	u	बुखार /bukār/	दुकान /dukān/	गुज़ारा /guzāra/

Data was recorded in a language lab or a quiet room to prevent noise using the Audacity software program (2.3.0.) with ASUS- X201E laptop computer. Then the recorded data was clipped by word unit and their VOT and VLT is measured using PRAAT software program. And all the values were tabulated for further analysis.

There are three contrasts in this paper. The first is the contrast between L1 Hindi and L1 Korean word-initial stop consonants to see how the feature of  $\pm$ VOT differs in both L1s; and the second is the contrast of L1 and L2 word-initial stop consonants, to see whether there is significant difference between the two Koreans and find influence of L1 Hindi to L2 Korean stops; and finally there is a contrast of L1 and L2 word-medial stop consonants to see the feature of differences, if it is, in terms of VOT durations. However, only the clearest token among the three tokens for each stimulus is selected and analyzed for the first and the second contrast for all 9 stop consonants with 3 adjoining vowels each, whereas for the third contrast, all three tokens for each stimulus are taken and analyzed, and for this contrast only Lax alveolar stop consonants of L1 and L2 Korean word-medial stops of three following vowels, which are /ta, ti, tu/, are analyzed.

### **3. Analysis and Discussion**

#### **3.1. Contrast of the total duration of $\pm$ VOT in Hindi and Korean stop consonant**

In this section, we will discuss how voicing property affects to the duration of articulation by contrasting Hindi and Korean stop consonant. All the 9 Korean stop consonants are voiceless at word-initial position. On the other hand, two types of Hindi stop consonants are voiced, i.e. Voiced Stop and Voiced Aspirated Stop, and they have voicing portion before the burst release. Thus the voice lead time (VLT, i.e. negative VOT) may affect any of the related articulation features, such as the plosion duration. To research this, total duration of  $\pm$  VOT in Hindi and Korean stop consonants are contrasted, and tabulated below. The duration for L1 Hindi stop consonants is the sum of VLT and VOT, and it is contrasted to VOT of L1 Korean stop consonant as Korean word-initial stop consonants do not have VLT portion. The results are given as in the table below.

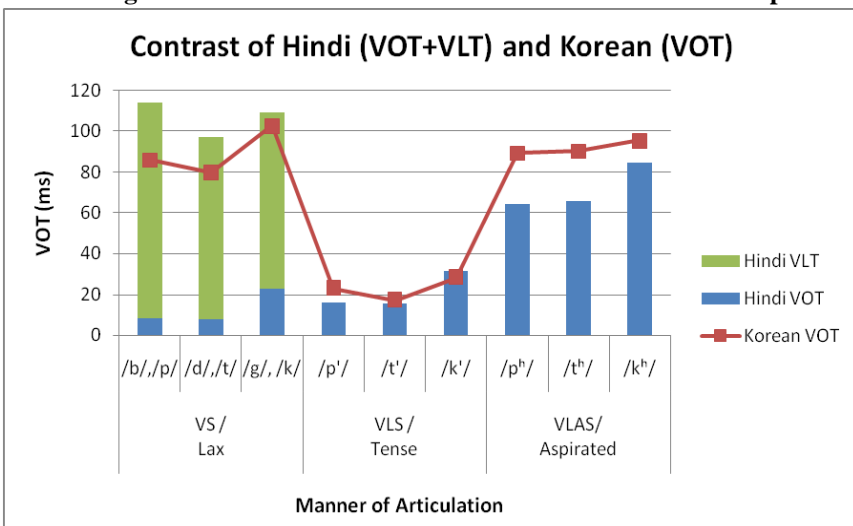
**Table 3: Contrast of  $\pm$ VOT duration of Hindi and Korean stops**

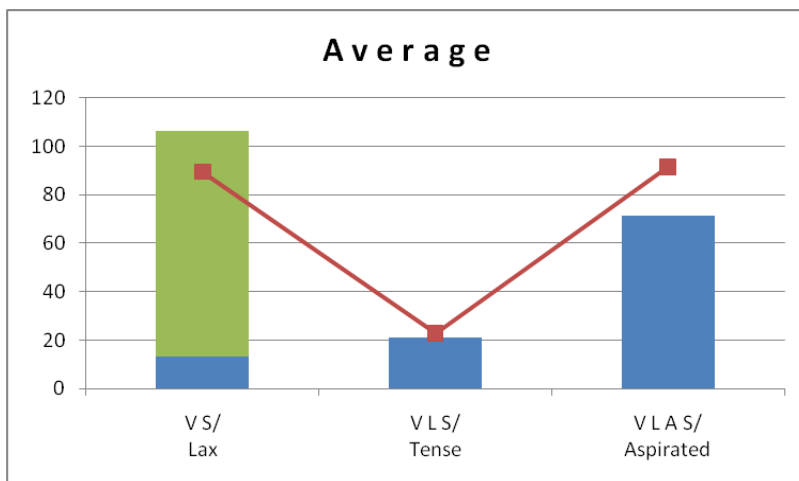
Manner of Articulation	Stops	L1 Hindi			L1Korean	Difference [ Hindi (VLT+VOT) -Kor.(VOT) ]
		VLT (-VOT)	VOT	VLT+VOT	VOT	
VS(H) / Lax(K)	/b,p/	105.3	8.4	113.7	85.9	27.7
	/d,t/	89.1	7.9	97.0	79.9	17.1
	/g,k/	86.2	22.5	108.8	102.7	6.1
	Ave.	93.6	12.9	106.5	89.5	17.0
VLS(H) / Tense(K)	/p'/	X	16.1	16.1	23.1	-7.0
	/t'/	X	15.3	15.3	17.2	-2.0
	/k'/	X	31.3	31.3	28.4	2.9
	Ave.	X	20.9	20.9	22.9	-2.0
VLAS(H) / Aspirated (K)	/p <sup>h</sup> /	X	64.2	64.2	89.2	-24.9
	/t <sup>h</sup> /	X	65.6	65.6	90.4	-24.7
	/k <sup>h</sup> /	X	84.3	84.3	95.3	-11.0
	Ave.	X	71.4	71.4	91.6	-20.2
Average		46.8	35.1	66.3	68.0	-1.8

Contrasting the VOT mean values of each stop type of L1 Korean stop consonants and corresponding L1 Hindi stop consonant by each stop type, the VOT duration of L1 Korean Lax stop is 89.5 ms, and that of corresponding L1 Hindi Voiced Stop consonants is 12.9 ms; and the duration of Korean Tense stop is 22.9 ms and that of Hindi Voiceless stop is 20.9 ms; and for Korean Aspirated stop is 91.6 ms, and for Hindi Voiceless Aspirated stop is 71.4 ms. In overall, Korean stop consonant has longer VOT than Hindi stop in all three stop types.

These values are plotted as follows.

**Figure 1:  $\pm$ VOT duration contrast of Hindi and Korean stop consonants**





**The feature of the total duration of  $\pm$ VOT in Hindi and Korean stop consonant**

- 1) Korean Lax stop consonants have long VOT duration. In contrast, the corresponding Hindi Voiced Stop (VS) consonants have the shortest VOT duration among the three stop types.
- 2) Hindi Voiceless stop (VLS) and Korean Tense stop have the shortest VOT duration, and have almost similar value.
- 3) In contrast, the VOT durations of Hindi Voiceless Aspirated stop (VLAS) and Korean Aspirated stop are very long, and Korean Aspirated stop has longer VOT duration than Hindi VLAS. It shows that there is a tendency of Korean speakers to pronounce aspirated stop consonants with much more aspiration than Hindi speakers.

Among the contrast of  $\pm$ VOT, the contrast of VS(Hindi)/Lax(Korean) shows the most different feature, because they have very different acoustic properties. Hindi Voiced Stop has significantly shorter VOT. It is because Hindi Voiced stop has VLT (i.e. negative VOT) portion before burst release and consumes the articulatory energy to produce the voicing portion, and causes relatively very short VOT duration. Therefore when the VLT (negative VOT) duration of Hindi VS consonant is added to its VOT duration, then the pattern of stop types becomes similar to Korean Lax Stop consonant as shown above in the diagram.

**3.2. Contrast of the VOT duration of L1 and L2 Korean word-initial stop consonant**

As seen above, Korea Lax stop and corresponding Hindi VS consonants have very different acoustic property in terms of VOT duration. Thus, Lax stop consonants of L2 Korean spoken by Hindi speakers may include phonation errors according to contrastive analysis hypothesis. To see the feature, the contrasts of L1 and L2 Korean stop consonants are conducted as below.

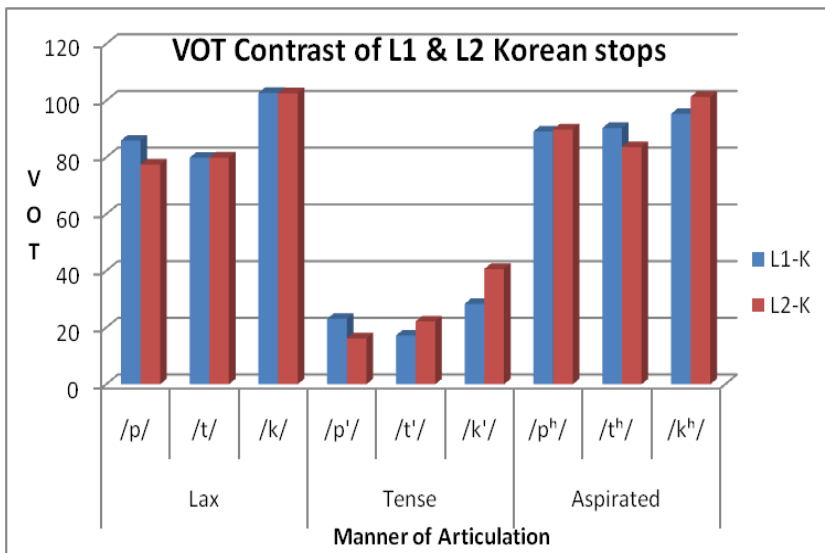
**Table 4: Contrast of VOT durations L1 and L2 Korean stops**

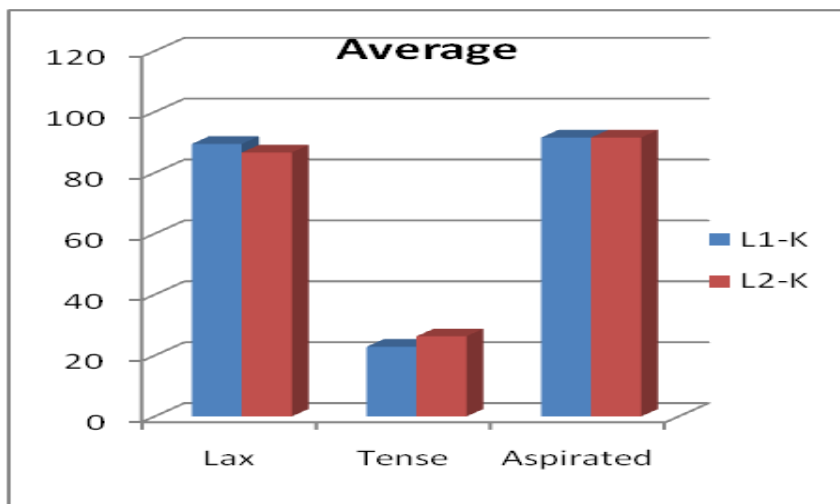
Manner of Articulation	Stops	L1Korean	L2 Korean	Difference [ L1 – L2]
		VOT	VOT	
Lax(K)	/p/	85.94	77.50	8.44
	/t/	79.90	79.95	-0.05
	/k/	102.72	102.63	0.09
	<b>Ave.</b>	<b>89.52</b>	<b>86.69</b>	<b>2.82</b>
Tense(K)	/p'/	23.11	16.17	6.94
	/t'/	17.23	22.15	-4.92
	/k'/	28.39	40.67	-12.28
	<b>Ave.</b>	<b>22.91</b>	<b>26.33</b>	<b>-3.42</b>
Aspirated (K)	/p <sup>h</sup> /	89.16	89.85	-0.69
	/t <sup>h</sup> /	90.36	83.63	6.73
	/k <sup>h</sup> /	95.34	101.35	-6.00
	<b>Ave.</b>	<b>91.62</b>	<b>91.61</b>	<b>0.01</b>
<b>Average</b>		<b>68.02</b>	<b>68.21</b>	<b>-0.19</b>

Contrasting the VOT mean values of L1 and L2 Korean stop consonants, the VOT duration of Lax stops for L1 Korean is 89.52 ms and it is 86.69 ms for L2 Korean; and that of Tense stops for L1 Korean is 22.91 ms and 26.33 ms for L2 Korean; and that of Aspirated stop consonants for L1 Korean is 91.62 ms and it is 91.61 ms for L2 Korean.

These values are plotted as follows:

**Figure 2: VOT duration contrast of L1 & L2 Korean stop consonants**





As shown in the table above, there are not many differences in the VOT duration of L1 and L2 Korean stop consonants. In previous section, we studied that Korean Tense and Hindi VS consonants have almost similar acoustic feature in terms of VOT, and Korean Aspirated stops have a bit longer VOT duration than Hindi VLAS consonants. However, in the case of Lax (Korean)/VS (Hindi) contrast, they have shown totally different acoustic features, so more phonation errors were expected in L2 Korean Lax stop consonants. Nevertheless, it seems like there is no interference of L1 Hindi VS on L2 Korean Lax stop consonant. It may be caused by the learners' phonetic knowledge for L2 Korean stop consonants that Korean stop consonants are all voiceless at word-initial position, since they have been learning Korean for more than 2 years. Thus when they were asked for the recording of the stop sound in given words, they might pay more attention to pronounce them properly.

Statistical analysis is conducted by using the statistics software R-program (R<sub>x64</sub> 3.5.3), to see whether there is a significant difference between the VOT durations of L1 and L2 Korean stop consonants. For the VOT contrast of Lax, Wilcoxon rank sum test is applied as the variables are non-normal distribution ( $p=0.02445$  of Shapiro-Wilk normality test), and the  $p$ -value for Lax is 0.5468. And the same test is applied for the contrast of Tense and Aspirated, as the variables are also non-normal distribution ( $p= 2.365e-07$  for Tense, and  $p= 0.0004873$  for Aspirated in Shapiro-Wilk normality test), and the  $p$ -value of the Wilcoxon rank sum test is 0.8591 for Tense, and it is 0.2121 for Aspirated. All the three  $p$ -values are much greater than the significance level of 0.05. Thus it can be said there is no differences between L1 and L2 Korean stop consonants in terms of VOT.

### **The feature of the contrast of L1 and L2 Korean stop consonants**

- 1) VOT durations of L1 Korean stop consonants and that of L2 Korean stop consonants are almost similar, and there is no such impact of L1 Hindi



stops to L2 Korean word-initial stop consonants in terms of VOT duration. It may be caused by the learners' phonetic knowledge for learning L2 that all Korean stop consonants are voiceless at word-initial position, thus they might pay more attention to pronounce them as voiceless sound.

However there may be phonetic interference of L1 Hindi. Thus, in order to confirm this assumption, we conducted additional contrast of stop consonants which are in such phonetic environment where the interference is likely to occur.

**3.3. Contrast of the VOT duration of L1 and L2 Korean word-medial stop consonant**

In this section, L1 and L2 Korean word-medial stop consonants, but only alveolar Lax stops with adjoining vowels of /a, i, u/, are contrasted. As studied in the introduction section, Korean stop consonants may be pronounced as voiced when they are placed between voiced sounds such as vowels. The tokens analyzed in this study are 'da' in '두 다/tuda/', 'di' in '디 디 다/tidida/' and 'du' in '구 두/kudu/'. The results are given below.

**Table5: Contrast of VOT durations of /t/ at word-intial and word-medial**

Alveolar Lax Stops	Word-initial			Word-medial		
	L1K-VOT	L2K-VOT	Difference [L1 – L2]	L1K-VOT	L2K-VOT	Difference [L1 – L2]
ㄷ/ta/	101.42	97.67	3.75	16.47	8.95	7.52 ms
디/ti/	62.64	65.45	-2.82	26.23	3.88	22.35 ms
두/tu/	75.64	76.73	-1.09	26.81	12.24	14.58 ms
<b>ㄷ/t/</b>	<b>79.90 ms</b>	<b>79.95 ms</b>	<b>-0.05</b>	<b>23.17 ms</b>	<b>8.36 ms</b>	<b>14.82 ms</b>

As discussed in 3.2, there is no statistical difference between L1 Korean and L2 Korean word-initial stop consonant. It is also consistent in the contrast of /t/ stops of this section. For the statistical verification, t-test was conducted, as the variables are normal distribution and equal variation, by using the statistics software R-program. The p-values of the t-test is 0.7478 for ㄷ/ta/, and it is 0.8135 for 디/ti/, and it is 0.9423 for 두/tu/. All the p-values are much greater than the significance level of 0.05. Thus, it can be said there is no statistical differences between L1 and L2 /t/ in terms of VOT.

However, in the case of word-medial contrast, L1 and L2 /t/ show significant differences, as the p-value of the t-test for ㄷ/ta/ is 0.0001223, and for 디/ti/ is 7.239e-14; and for 두/tu/ is 5.487e-07. All the three p-values are much less than the significance level of 0.05. Thus the differences are very significant.

The result shows that;

- 1) The VOT durations of word-medial stop consonants in L1 and L2 Korean are significantly shorter than that of word-initial stop consonants. They are 79.9ms vs. 23.17 ms for L1 Korean, and 79.95 ms vs. 8.36 ms for L2 Korean. Although the tokens are of Lax stop consonants, their VOT durations are similar to the duration of Tense stops.
- 2) However, the phenomena of shortening of VOT duration at word-medial position happen in different aspects in both Korean stops. The Hindi speakers' L2 Korean stop consonants positioned between voiced sounds (vowels) becomes voiced stops, and it causes the significant shorting of VOT duration. This phenomenon is similar to what happens in Hindi voiced stop. Of the 45 word-medial L2 Korean stops /ta, ti, tu/ pronounced by Hindi speakers, 38 were pronounced as voiced stop consonants [da, di, du]. This aspect shows that even though Hindi speakers know how to pronounce the L2 Korean stop consonants sound properly (as already studied in 3.2), they spontaneously pronounce L2 Korean stops according to the phonation patterns of Hindi stops, under a phonetic environment similar to Hindi stops.
- 3) In contrast, the shortening feature of VOT duration for L1 Korean word-medial stop consonant is different from that of L2 Korean. Comparing the VOT duration of L1 and L2 Korean word-medial stops, both are shortened than the case of word-initial stops, however, L1 Korean has relatively longer VOT duration (23.17 ms) than that of L2 Korean stops (8.36 ms). It is because Korean native speakers tend to pronounce the shortened word-medial stop sounds similar to Tense stops (as in the Table 4, the VOT duration of Korean Tense stop consonants are greater or less than 20 ms), instead to pronounce them as voiced sound like Hindi native speakers do. Of the 45 L1 Korean stops of /ta, ti, tu/ at word-medial position, only 1 case was pronounced as voiced sound [da, di, du], and other 44 case were pronounced similar to tensed sound [t'a, t'i, t'u] in terms of VOT duration. It is because there is no voiced sound in Korean stop consonants; accordingly, Korean native speakers are not familiar with pronouncing voiced sound. Therefore, even though voiceless stop consonants are positioned between voiced sounds, where the voiceless sounds become easily voiced, Korean speakers hardly pronounce them as voiced sounds.

#### **4. Main findings and Pedagogical implications**

- 1) In the contrast of L1 Korean stops and L1 Hindi stop consonants, Lax (Korean)/ VS (Hindi) showed the most different feature in terms of VOT duration.
- 2) Hindi Voiceless stop (VLS) and Korean Tense stop have have almost similar feature in VOT duration.
- 3) Korean Aspirated stops have longer VOT duration than corresponding Hindi Voiceless Aspirated stop (VLAS).

- 4) The VOT duration of L1 Korean stops and L2 Korean stops of Hindi speakers are very similar in all three stop types.
- 5) The VOT durations of word-medial stop consonants are significantly shorter than that of word-initial stop consonants in both L1 and L2 Korean.
- 6) The shortening aspects at a word-medial stop consonant appear differently in Hindi speakers L2 Korean and L1 Korean. The feature of shortening of VOT is similar to the phonation pattern of the speakers' L1. In the case of L1 Korean, the VOT durations are shortened as they become similar to the acoustic features of tensed stops. On the other hand, in the case of the same stops of L2 Korean, the VOT is also shortened as they become voiced sounds, in most case. It is because Hindi speakers are familiar to pronounce voiced sound; thus, unlike Korean speakers, Hindi speakers pronounce L2 Korean voiceless stop which is between vowels as voiced sound. It shows that there is interference of L1 Hindi to L2 Korean stop consonants in terms of VOT duration. It may be caused by the learners' phonetic knowledge for learning L2 that all Korean consonants are voiceless, thus might pay more attention to pronounce them accurately. However, in a familiar phonetic environment, Hindi speaking L2 Korean learners follow their accustomed phonation patterns as in L1 Hindi stops. Although both of the VOT duration of L1 and L2 Korean stop consonants are shortened at word-medial position, the aspects are different. L1 Korean Lax stops are shortened as they become similar to Tensed stops, whereas in the case of L2 Korean Lax stops, the shortening happens as they become voiced sounds.

### **Bibliography**

- Brown, Douglas H. *Principles of Language Learning and Teaching*, 4th edition, White Plains, NY, Pearson Education, 2000.
- Cho T., & Ladefoged, P. "Variation and Universals in VOT: Evidence from 18 Languages." *Journal of Phonetics*, vol. 27, 1999, pp. 207-229.
- Cho, & Yong-Hyung. "VOT and its Effect on the Syllable Duration in Busan Korean." *Speech Science*, Vol. 12, no. 3, 2005, pp. 153-164.
- Dulay, Heidi C., et al. *Language Two*. New York, Oxford University Press, 1982.
- Dutta, Indrani. "Four Way Stop Contrast in Hindi: An Acoustic Study of Voicing, Fundamental Frequency and Spectral Tilt." *Ph.D. Thesis*, Urbana, Illinois.
- Jang, Hyejin. "Acoustic Properties and Perceptual Cues of Korean Word-initial Obstruent." *Ph.D. Dissertation*. Korea, Korea University.
- Kang, Soon-ja and Sang-ho Lee. "Acoustic Properties of Word-initial Korean Stops in Speech Perception." *Speech Science*, Vol. 9, no.2, 2002, pp. 1-20.
- Kang, Y. "Voice Onset Time Merger and Development of Tonal Contrast in Seoul Korean Stops-A Corpus Study." *Journal of Phonetics*, Vol. 45, 2014, pp.76-90.

- Keating, Patricia A. "Phonetic and Phonological Representation of Stop Consonant Voicing." *Language* 60, 1984, pp. 286-319.
- Kim, Miryoung. "The Relationship between Cross Language Phonetic Influences and L2 Proficiency in Terms of VOT." *Phonetics and Speech Sciences*, Vol.3, no. 3, 2011, pp. 3-10.
- Kim, Mi-Ryoung. "L1-L2 Transfer in VOT and f0 Production by Korean English Learners: L1 Sound Change and L2 Stop Production." *Phonetics and Speech Sciences*, Vol. 4, no. 3, 2012, pp. 31-41.
- Lisker, L., & Abramson, A. "Across Language Study of Voicing in Initial Stops: Acoustical Measurements." *Word*, Vol.20, 1964, no.3.
- Narang, Vaishna (Module 10) Introduction to Phonetics and Phonology, In MHRD,ePathshala/ Linguistics, Paper 02. Introduction to Phonetics and Phonology. [https://epgp.inflibnet.ac.in/view\\_f.php?category=1306](https://epgp.inflibnet.ac.in/view_f.php?category=1306).
- Narang, Vaishna (Module 16) Instrumentation and Technology in Acoustic Phonetics, In MHRD,ePathshala/ Linguistics, Paper 02. Introduction to phonetics and phonology.[https://epgp.inflibnet.ac.in/view\\_f.php?category=1306](https://epgp.inflibnet.ac.in/view_f.php?category=1306)
- Port, Robert F., and Rotunno, Rosemarie. "Relation between Voice-onset Time and Vowel Duration." *The Journal of the Acoustical Society of America*, Vol.66, 1979, pp. 654-662.
- Selinker, Larry. *Rediscovering Interlanguage*. New York, Longman Inc., 1992.
- Shin, Jiyoung, et al. *The Sounds of Korean*. New York, Cambridge University Press, 2013.
- Silva, D. J. "Variation in Voice Onset Time for Korean Stops: A Case for Recent Sound Change." *Korean Linguistics*, Vol. 13, 2006, pp.1-16.

