An Acoustic Analysis on the Plosives of Korean and Japanese

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1. Introduction

In diagnosing the phonetic basis for our ability to distinguish among phonetic categories, linguists often invoke the dimension of voicing to call some categories "voiced" and others "voiceless". With respect to the plosive consonants, it is usual to label as voiced, which is characterized by the presence of glottal buzz during the interval of articulatory closure. While absence of buzz during this interval is a mark of voiceless plosives.[1] Korean is a peculiar language, in the sense that its nine plosive consonants fall on the voiceless side, leaving the voiced side empty. They are classified in three places of articulation (labial, alveolar, velar), and also in three manners of articulation: type I "slightly aspirated lax /p, t, k/", type II "unaspirated and tense /p*, t*, k*/", type III "heavily aspirated and tense /p^h, t^h, k^h/". All of them represent themselves as voiceless word-initially, while type I (lax) become voiced in inter-sonorant positions. It has been pointed out that Korean plosives cannot be

1) See Lisker and Abramson(1964), "A Cross-language Study of Voicing in Initial Stops: Acoustical Measurements," in *Word 20*, p.384

distinguished in terms of voicing only, but the feature "tensity" must be taken into consideration.

In Japanese, however, there are six plosives, showing a typical voicing contrast : "voiced /b,d,g/" versus "voiceless /p,t,k/". According to Kohler(1984), "if a language only has a two-way opposition between the obstruent classes /b,d,g etc./ and /p,t,k etc./, members of the second set are auditorily more salient than members of the first, because of higher intensity at certain points in the acoustic signals."

The problem to be dealt with in this paper is two-fold: (a) What are the acoustic temporal properties of Korean and Japanese plosives? (b) How the speakers perceive and produce plosives which are lacking in their native language?

2. Experimental procedure

Three male native Korean speakers from Seoul dialect who can speak Japanese and three male native Japanese speakers from Tokyo dialect who can speak Korean served as the informants of the experiment.

The structure of the test words are CV and VCV in which plosives occur word-initially and medially. They are all meaningful words with some exceptions in order to get natural fluency.

<Korean>

-CV-

/pam/ 'night'	/p*am/ 'sucking'	/p^{h}am/ 'digging'
/tam/ 'wall'	/t*am/ 'sweat'	/t^{h}am/ 'eagerness'
/kam/ 'persimmon'	/k*am/ 'laying'	/k^{h}am/ nonsense

-VCV-

/aba/ nonsense	/ap*a/ 'daddy'	/ap^{h}a/ 'pain'
/madang/'garden'	/mat*ang/ 'suitable'	/mat^{h}ang/ 'sweet potato'
/aga/ 'baby'	/ak*a/ 'beforehand'	/ak^{h}a/ nonsense

<Japanese>

-CV-

/baN/ 'number'	/paN/ 'bread'
/daN/ 'platform'	/taN/ 'phlegm'
/gaN/ 'cancer'	/kaN/ 'feeling'

-VCV-

/uba/ 'nurse'	/upa/ nonsense
/mada/ 'yet'	/mata/ 'crutch'
/agari/ 'rising'	/akari/ 'light'

The test words are presented in orthography (Hangul and Kana respectively) on randomized separate cards. Each test word is read five times. To prevent influences of neighboring sounds, no carrier sentence was presented. These 900 samples (30 words x 6 informants x 5 times) were recorded on a metal cassette tape in a sound-proof room. They were analyzed by the SoundEdit Application of a Macintosh computer. Following A/D conversion they were scanned on a graphic display allowing forward and backward shift as well as time and amplitude expansion. I segmented and measured the duration of the preceding vowel, closure, VOT, and the following vowel on the soundwave. The mean values are t-Tested statistically.

In perception test, the recorded Japanese natural sounds were presented to 56 Korean native speakers. They were asked to indicate which sound he or she heard.

3. Results

3.1. /CV/ syllables

Plosive sounds are produced by oral occlusion followed by release burst. As the occlusion phase is not presented on the soundwave, the only measurable temporal property is the VOT (voice onset time), the interval between the release burst of the stop and the first quasi periodicity of the following vowel. The voicing lags in voiceless obstruents, and it leads in voiced obstruents. The audible noise which appears during this voicing lag is the aspiration. Sometimes, aspiration is expanded to the first part of the following vowel.

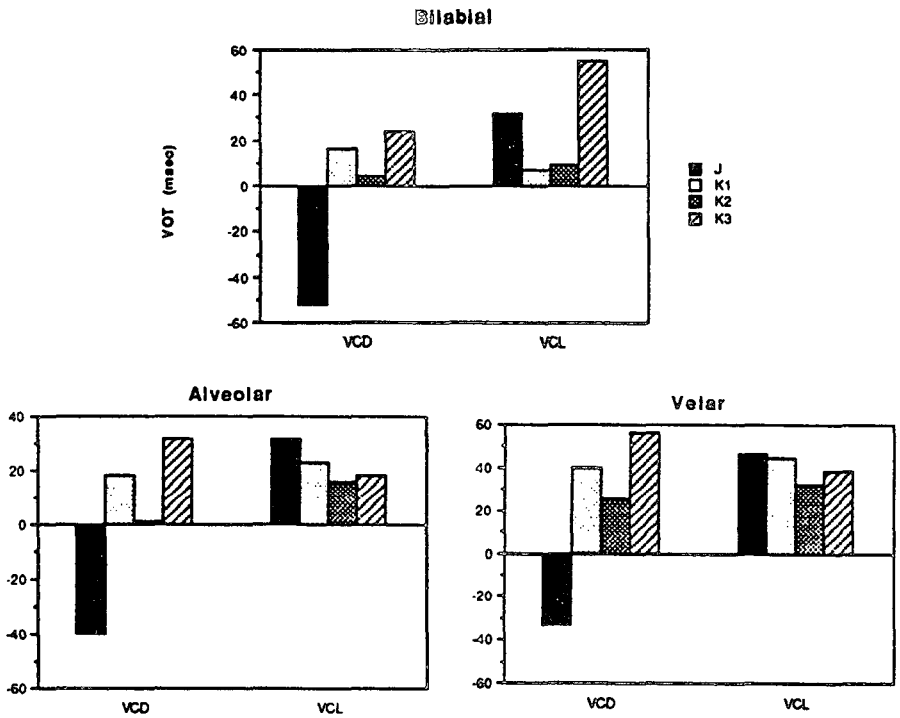
The VOT mean value of the 5 types of plosives are presented in <Table 1>. The Japanese voiceless type has longer voicing lag than that of Korean lax type, but shorter than that of Korean aspirated type.

<Table 1> The voicing onset time of initial plosives (in msec).

	Korean			Japanese	
	Lax	Unasp	Asp	Vcd	Vcl
Bil	24	9	78	-52	32
Alv	29	11	75	-40	32
Vel	42	15	89	-33	47

One more interesting phenomenon is that Korean speakers generally fail in prevoicing when producing initial voiced plosives, which are lacking in his native language, as is shown in <Figure 1>. Generally, Korean speakers produce and perceive Japanese voiced plosives as lax unaspirated ones, and voiceless plosives as slightly aspirated and tense in initial position.

<Figure 1> The voicing onset time of Japanese initial plosives spoken by Korean, compared to those by Japanese native speakers.
(J= Japanese informants, K1= the first Korean informant, K2= the second Korean informant, K3= the third Korean informant)



3.2. /VCV/ syllables

As I have said before, Korean lax plosives become voiced (sometimes partially voiced) in voiced environments, having negative VOT value. And the aspiration length of the medial aspirated type is shorter than that of the initial counterpart. From the analyses of medial plosives, we find two crucial temporal properties in distinguishing Korean consonant types which will be attested in perception test: the length of preceding vowel and the

closure duration for the plosive consonant. As is shown in <Table 2>, the preceding vowel of type I is longer than that of type II and type III. while the closure duration of type II and III is far longer than that of type I. The relatively shorter preceding vowel and the longer closure duration are properties of the tense obstruents.

The duration ratio of $\frac{\text{the length of the preceding vowel}}{\text{precedign vowel + closure duration}}$ is a relevant cue in producing and perceiving a consonant type and is one of the important language-specific features[2]. This duration ratio for Korean type I: type II: type III is 0.63: 0.30: 0.35. It sharply distinguishes type I from type II and III, which shows tensity opposition. In Japanese, the ratio for voiced:voiceless is 0.69: 0.45.

Since Korean speakers are accustomed to medial voiced variants, they easily produce Japanese medial voiced plosives.

<Table 2> The mean value of each components of bilabial plosives in medial position.

	Korean			Japanese	
	Lax	Unasp	Asp	Vcd	Vcl
V1	114	75	80	98	77
CL	72	183	150	47	99
VOT	-42	9	47	-47	11
V2	290	281	251	126	111
V1/(V1+CL)	0.61	0.29	0.35	0.66	0.44

V1= preceding vowel VOT= voice onset time
CL= closure duration V2 = following vowel
V1/(V1+CL) = duration ratio of $\frac{\text{preceding vowel}}{\text{preceding vowel+closure duration}}$

2) See Zhi and Lee(1990) p.370 and Kohler(1979) p.337

As for Japanese informants, they sometimes show confusion between type II and type III medially as well as initially. As Japanese is a two-way distinction language (voiced: voiceless = lax:tense), the difference between presence and absence of aspiration in tense consonants is phonologically unimportant. The same phenomena are found in English, where both aspirated /p/ (as in 'pin') and unaspirated /p/ (as in 'spin') are the same phoneme.

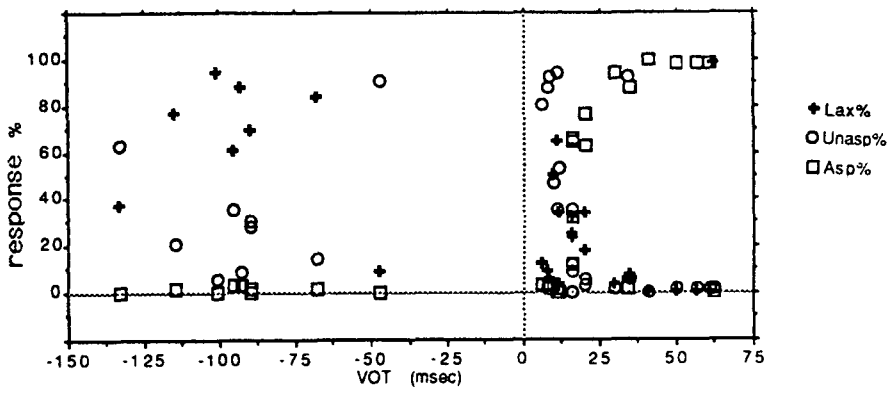
3.3. Perception test

It has been observed that speakers tend to adapt foreign sounds to their native language system when they produce or perceive strange sounds.

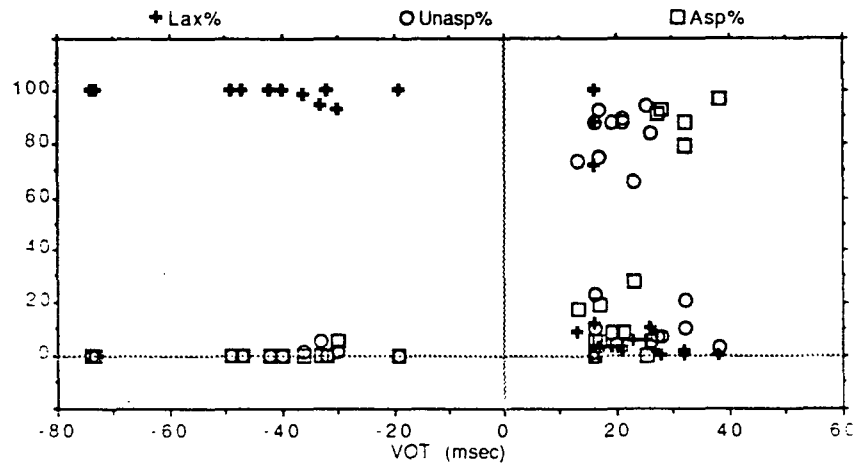
In <Figure 2>, we see that Korean speakers perceive Japanese initial voiced plosives as Korean lax (Type I) or sometimes unaspirated(Type II) ones. It means that Korean speakers can't distinguish initial plosives on the VOT scale from -70 to 25 msec by the voicing only. I assume that the strange unaspirated initial voiced plosives were perceived as Korean type II (unaspirated and tense) by Korean speakers. On the other hand, they sharply distinguish voiced plosives from voiceless ones in medial positions. In addition, they adopt the duration ratio of V1/(V1+CL) in distinguishing tense plosives from lax ones, and then mapping them on type II or type III according to their aspiration length.

<Figure 2>

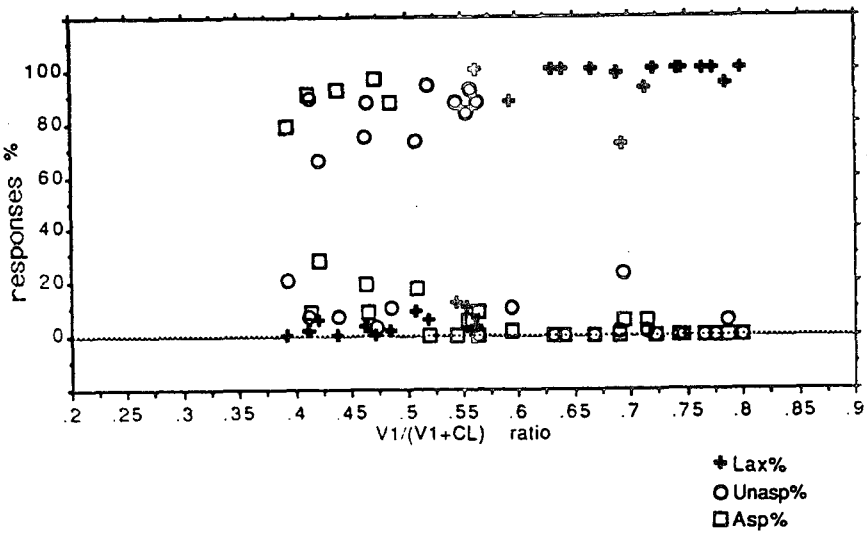
a. Percentage response Korean speakers as a function of VOT, for Japanese initial bilabial plosives under conditions Lax(+), Unaspirated tense(o), Aspirated Tense(□).



b. Percentage responses as a function of VOT, for Japanese medial velar plosives.



c. Percentage responses as a function of the duraton ratio of V1/(V1+CL), for Japanese medial velar plosives.



4. Conclusions and Discussions

The main purpose of this paper was to compare the acoustic properties of Korean and Japanese plosive sounds. The result are as follows:

(a) The VOT of Korean aspirated type is longer than that of Korean lax type and far longer than that of unaspirated type in initial position.

(b) The aspiration length of Japanese voiceless plosives is longer than that of Korean lax type and shorter than that of Korean aspirated type in initial position.

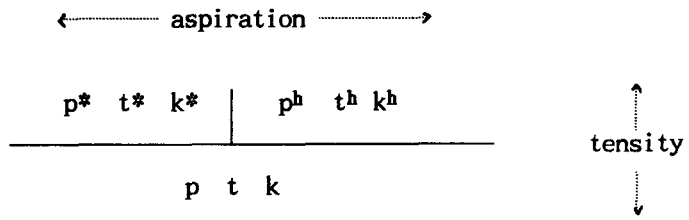
(c) The duration ratios of Korean lax: unaspirated: aspirated type is, for the preceding vowel 1: 0.66: 0.67, for the closure duration 1: 2.61: 2.15, for V1/(V1+CL) 0.63: 0.30: 0.35 respectively.

(d) The duration ratio of V1/(V1+CL) in Japanese voiced: voiceless is 0.69: 0.45.

(e) Korean speakers fail to distinguish initial voiced plosives from Korean lax ones, although they are sharply differentiated in terms of VOT.

(f) Japanese speakers sometimes fail to distinguish Korean aspirated type from unaspirated type, both of which are tense.

It leads to the following arrangement of the three types of Korean itinial plosives[3]:



Lax type is different from the unaspirated type and the aspirated type in the duration ratio of the preceding vowel and closure of the consonant, which is involved in the tensity opposition. The voicing lag, i.e.,, the aspiration length, plays an important rule to differentiate the aspirated type from the unaspirated type.

Perceptually, Korean speakers generally map Japanese plosives on Korean ones as below.

Japanese		Korean
/b/	.....	/p/
/p/	.....	/p*, p^h/

Originally, I wanted to see how Korean speakers perceive Japanese sounds, I

3) See Kim(1965), "On the Autonomy of Tensity Feature in Stop Classification", Word 21.3, p.358

utilized raw materials of Japanese natural sounds. In order to decide the effects of each variables, we should have used synthesized sounds with keeping one variable constant and differentiate the other variable in several steps.

I admit that this experiment was limited to the temporal properties. If it is expanded to the Fo of the vowel following a consonant and the aerodynamic aspects, we can explain the properties of the plosives in the two languages more adequately.

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<국문초록>

본 논문에서는 한국어에 있어서 세 가지 유형의 파열음과 일본어에 있어서 두 가지 유형의 파열음과 일본어에 있어서 두 가지 유형의 파열음이 보여주는 시간적 특성을 어두 위치 및 모음간 위치로 나누어 비교해 보았다.

한국어에 있어서 세 가지 유형의 파열음은 어두 위치에서 모두 무성음으로 실현되므로 성의 대립으로는 이들을 유형화 할 수 없고, 그보다는 조음의 힘과 기식의 유무에 따라 연음, 무기 경음, 유기 경음으로 분류하는 것이 타당하다. 이에 비해 일본어 파열음은 유성음인 연음과 무성음인 경음의 두가지 유형으로 대립된다.

유성음과 무성음, 그리고 유기음과 무기음의 구분에는 파열음의 개방에서부터 성대 진동까지의 시간인 성 시작 시간(VOT)과 기식의 길이가 변수가 된다. 경음과 연음의 구분에는 선행 모음의 길이, 폐쇄 지속 시간, V1/(V1+CL)의 비율이 유용한 정보가 된다. 양국어 어두 파열음의 VOT를 비교해 볼 때, 일본어 유성음은 음수의 VOT를 가지며, 한국어 무기 경음에서는 VOT가 10msec정도로 짧게 나타나고, 그 다음으로 한국어 연음, 일본어 무성음, 한국어 유기 경음의 순서로 길어진다.

$$\frac{\text{선행 모음의 길이}}{\text{선행 모음의 길이+폐쇄 지속 시간)}}$$

의 비율은 언어의 특성도 반영해 주는데, 한국어의 경우 연음: 무기 경음: 유기 경음의 비는 0.63: 0.30:0.35, 일본어의 경우 유성음:무성음의 비는 0.69: 0.45로 나타났다.

청취 실험을 통해 한국인의 자음 인식 경향을 살펴본 결과, 성대 진동의 유무를 변별적으로 사용하지 않는 한국인 화자는 일본어 유성음은 연음으로, 무성음은 경음으로 인식하는 경향이 있는 것으로 나타났다.