Phonetically Based Consonant Cluster Acquisition Model[1)]

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음성학을 토대로 한 자음군 습득 모형

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Abstract

Second language learners' variable degree of production difficulty according to the cluster type has previously been accounted for in terms of sonority distance between adjacent segments. As an alternative to this previous model, I propose a *Phonetically Based Consonant Cluster Acquisition Model* (PCCAM) in which consonant cluster markedness is defined based on the articulatory and perceptual factors associated with each consonant sequence. The validity of PCCAM has been tested through Korean speakers' production of English consonant clusters.

I. Introduction

Previous studies on the production of English consonant clusters by second language (L2 hereafter) learners have reported that L2 learners insert a vowel or delete a consonant to break down non-native consonant clusters.[1],[2] In particular, it has been reported that certain consonant sequences are more problematic for L2 learners than other sequences. For instance, it was found that Korean speakers insert an epenthetic vowel more often in voiced stop + liquid clusters than in voiceless stop + liquid clusters.[1]

To account for the difficulties that L2 learners face in the production of nonnative consonant clusters, particularly regarding the variable degree of production difficulty according to the cluster type, Broselow & Finer propose the Minimal Sonority Distance Parameter which refers to sonority distance between adjacent segments in determining consonant cluster markedness.[1] Note that in L2 research, consonant cluster markedness is assumed to determine learners' production difficulty with non-native consonant sequences: the more marked the cluster is, the more likely L2 learners produce errors.

However, Davidson argued that defining consonant cluster markedness on the basis of sonority is not an adequate predictor of L2 learners' performance on non-native consonant clusters.[3]

With respect to the contradiction between the predictions of sonority-based models and L2

1) This article is an excerpt (Section 1.1-1.2, Section 4.3, Section 6.2-6.4, Section 7.1, Section 8) from the author's unpublished Ph.D dissertation, *Korean speakers' production of English consonant clusters: Articulatory and perceptual accounts.*

learners' production data, two sets of data are worth highlighting. First, /s/ + stop onset clusters, which are assumed to be the most difficult onset clusters in English according to the sonority-based model (due to sonority reversal), actually induce fewer errors than other onset clusters.[4],[5]

Second, several studies reported that coda clusters with sonority reversal (e.g., /ps, ts, ks/) induce fewer errors than /s/ + stop coda clusters (/sp, st, sk/) which follow the sonority sequencing principle.[5],[6],[7],[8] Note also that children seem to acquire stop + /s/ coda clusters earlier than /s/ + stop coda clusters.[9],[10],[11],[12],[13]

In this study, I suggest that the near-failure of the sonority-based model in L2 acquisition of consonant clusters can be attributed to the lack of phonetically natural explanations for the consonant cluster markedness. For instance, the relative unmarkedness of /s/ + stop onset clusters may be problematic under the sonority-based model, but when referring to the phonetic factors associated with /s/ + stop onset clusters, it can be understood why vowel insertion and consonant deletion, two major error types in L2 learners' consonant cluster production, are not likely to occur in /s/ + stop onset clusters.

Thus, the main purpose of this study is to show that the principles governing the acquisition of L2 phonotactics are grounded in the universal aspects of speech production and perception shared by human beings. More specifically, this study identifies a) articulatory difficulty inherent in a certain segment and segmental sequences and b) perceptual similarity differences between the modified form and its unmodified counterpart as two major forces shaping phonological constraints in consonant cluster acquisition. This study empirically tests the existence of universal principles governing the acquisition of L2 phonotactics by constructing the *Phonetically Based Consonant Cluster Acquisition Model* (PCCAM). It also tests PCCAM through Korean speakers' production of English consonant clusters.

II. Phonetically Based Consonant Cluster Acquisition Model (PCCAM)

PCCAM is based on the assumption that phonological markedness may be phonetically grounded. The main tenet of the phonetically based phonological markedness is that there is a connection between markedness patterns and constraints governing the production and perception of speech.[14]

From the perspective of the phonetically based markedness, second language learners' modification (i.e., errors) of non-native L2 consonant sequences can be viewed as being derived from learners' articulatory difficulty with producing such a sequence, while the specific contexts targeted by L2 learners (e.g., the site of vowel insertion, or a segment being deleted) are often attributed to perceptual factors.

On the theoretical side, PCCAM draws on insights from Articulatory Phonology[15] and the P-map[16],[17] to determine how articulatory and perceptual factors influence L2 learners' non-native consonant cluster production. Under these frameworks, eight phonetic factors governing the production of consonant clusters are identified as follows.

(1) Articulatory factors in PCCAM[2)]
a. Degree of gestural overlap
b. Articulatory release effect
c. Articulatory stridency effect
d. Articulatory voicing effect

(2) Perceptual factors in PCCAM
a. Perceptual stridency effect
b. Perceptual voicing effect
c. Principle of perceptual saliency
d. Maximal perceptual contrast

Based on these eight phonetic factors, the relative difficulty of producing consonant clusters in PCCAM is calculated through a three-way computation of consonant cluster markedness: a) markedness of C_1 (the first consonant in a cluster), b) markedness of C_2 (the second consonant in a cluster), and c)

2) This article cannot present the definition of each phonetic factor due to the limited space. Readers are referred to Chapter 4 of the author's dissertation.

markedness of the gestural coordination of C_1 and C_2. The consonant cluster markedness hierarchy generated by PCCAM is presented in Table 1.

Table 1. Consonant cluster markedness hierarchy in PCCAM

less marked <more marked; // no markedness relationship	
Onset clusters	sp, st, sk < sm, sn < sl < pl, pr, tr, kl, kr < bl, br, dr, gl, gr
Coda clusters Sonorant + C	ls, ns, < lz, nz // lp, lt, lk, np, nt, mp < lb, ld, nd // lm
Coda clusters Obstruent + C	ps, ts, ks < sp, st, sk < pt, kt // bz, gz < zd < bd, gd

Table 1 shows that when it comes to onset clusters, /s/ + stop is the least marked while voiced stop + liquid is the most marked. Regarding obstruent + C coda clusters, PCCAM predicts that voiceless stop + voiceless strident is least marked, while voiced stop + voiced stop is most marked.

To test the validity of PCCAM as a predictor of L2 learners' performance on non-native consonant clusters, a production experiment involving 30 Korean EFL (English as a Foreign Language) students was implemented.

III. Production Experiment

(1) Experimental design

At the time of the experiment, all participants were taking the same courses provided by the English department, and most of the participants were English language and literature majors or minors. They were in the second or third year of college, and their ages ranged from 21 to 27.

Two-member onset and coda consonant clusters in English are tested in the production experiment. The structures of the words are CCVC and CVCC for target words, and VCCV for fillers. A filler was inserted after every three words. Participants were encouraged to read the nonsense words as if they were real English words. Each word was presented to the participants on index cards one at a time, but a mixed order was kept to make sure there was no order effect. The participants read each word embedded in a carrier phrase "I am saying___" The experiment was recorded on a Marantz PMD 201 cassette recorder, using an Audio-Technica ATR35s microphone.

To see whether the difference in the number of errors depending on the cluster type is statistically significant, a pairwise Pearson chi-square test was implemented. Chi-square results were computed using SPSS (version 12.0), and significance at $p \leq .05$ was assumed. Statistically significant pairs are indicated by * at $p \leq .05$ level, ** at $p \leq .01$ level, and *** at $p \leq .001$ level.

(2) Results

The first column of Table 2 presents the relative markedness relationships in PCCAM, and the second column lists the phonetic factors defining each markedness relationship. For instance, we can see that the relative markedness relationship between voiceless stop + voiceless stop and voiced stop + voiced stop (pt, kt < bd, gd) is defined by the articulatory voicing effect and perceptual voicing effect.

The third column presents the results from Korean speakers' production of English consonant clusters. For instance, among onset clusters voiced stop + liquid (13.1%) induced the most errors, while /s/ + voiceless stop (0.6%) induced the least errors. On the other hand, among obstruent + obstruent coda clusters, voiced stop + voiced stop (55.1%) induced the most errors, while voiceless stop + /s/ (12.4%) induced the least errors. Note that these results exactly match the consonant cluster markedness hierarchy in PCCAM.

The shaded areas in the third column indicate the three cases (out of 13) where the predictions of PCCAM were not supported in Korean speakers' production: /s/ + stop vs. /s/ + nasal, /s/ + liquid vs. voiceless stop + liquid, and /s/ + voiceless stop vs. voiceless stop + voiceless stop. Yet, it should be noted that the error rate differences between /s/ + stop vs. /s/ + nasal and /s/ + liquid vs. voiceless stop + liquid are not statistically significant. Thus, I think the real problematic case to the prediction of PCCAM is the relative markedness relationship between /s/ + voiceless stop and voiceless stop + voiceless stop.

Table 2. Korean speakers' production of English consonant clusters

Relative markedness relationship	Phonetic factors	Production results	Statistical significance
Onset			
sp, st, sk < sm, sn	a. maximal perceptual contrast b. articulatory stridency effect c. perceptual stridency effect	sp, st, sk (0.6%) < sm, sn (0.4%)	p = .819
sm, sn < sl	a. maximal perceptual contrast b. perceptual stridency effect	sm, sn (0.4%) < sl (6.7%)	$p = .000^{***}$
sl < pl, pr, tr, kl, kr	a. articulatory stridency effect b. perceptual stridency effect c. degree of gestural overlap	sl (6.7%) < pl, pr, tr, kl, kr (3.4%)	p = .088
pl, pr, tr, kl, kr < bl, br, dr, gl, gr	a. articulatory voicing effect	pl, pr, tr, kl, kr (3.4%) < bl, br, dr, gl, gr (13.1%)	$p = .000^{***}$
Coda			
ls, ns < lz, nz	a. articulatory voicing effect	ls, ns (8.1%) < nz (11.4%)	p = .308
ls, ns < lp, lt, lk, np, nt, mp	a. articulatory stridency effect b. principle of perceptual saliency c. degree of gestural overlap	ls, ns (8.1%) < lp, lt, lk, np, nt, mp (13.6%)	$p = .028^{*}$
lp, lt, lk, np, nt, mp < lb, ld, nd	a. articulatory voicing effect	lp, lt, lk, np, nt, mp (13.6%) < lb, ld, nd (25.2%)	$p = .000^{***}$
lp, lt, lk, np, nt, mp < lm	a. maximal perceptual contrast	lp, lt, lk, np, nt, mp (13.6%) < lm (74.5%)	$p = .000^{***}$
ps, ts, ks < sp, st, sk	a. principle of perceptual saliency b. degree of gestural overlap c. articulatory release effect	ps, ts, ks (12.4%) < sp, st, sk (27.4%)	$p = .000^{***}$
sp, st, sk < pt, kt	a. articulatory stridency effect b. degree of gestural overlap	sp, st, sk (27.4%) < pt, kt (17.4%)	$p = .005^{**}$
pt, kt < bd, gd	a. articulatory voicing effect b. perceptual voicing effect	pt, kt (17.4%) < bd, gd (55.1%)	$p = .000^{***}$
bz, gz < zd	a. principle of perceptual saliency b. degree of gestural overlap c. articulatory release effect	bz, gz (39%) < zd (53.5%)	$p = .011^{*}$
zd < bd, gd	a. degree of gestural overlap	zd (53.5%) < bd, gd (55.1%)	p = .785

The error rate difference in these clusters is opposite to the prediction of PCCAM, and the error rate difference is also statistically significant. It may be that PCCAM needs to incorporate more phonetic factors to explain the special status of /s/ + voiceless stop coda clusters.

IV. Conclusion

This study investigated the roles and interactions of articulatory and perceptual factors in Korean speakers' production of English consonant clusters. This study has shown that the consonant cluster acquisition model constructed based on articulatory and perceptual factors associated with each consonant sequence (i.e., PCCAM) serve as a good predictor of Korean speakers' production of English consonant clusters. In addition, since the universal characteristics of phonetic factors are identified in PCCAM, the model has the potential to explain consonant cluster acquisition data from a variety of

L1s and L2s. In other words, PCCAM provides a good testing ground for the existence of the universal aspects of articulation and perception shared by human beings. This study provided a test case for the existence of such commonalities.

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