# Typological Universals and Intrinsic Universals on the L2 Acquisition[1] of Consonant Clusters[2]

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## Abstract

This study is to examine if typological universals built upon primary languages are applicable to interlanguage data in SLA. Implicational universal is considered the classic example of a typological universal by Croft (2003). Thus, the Interlanguage Structural Conformity Hypothesis, which consists of two implicational universals proposed by Eckman (1991), were tested against data from an interlanguage. The interlanguage data reconfirms that syllable structure plays a key role in the Fricative-Stop Prinicple. However, the Fricative-Stop Principle is sensitive to the position which clusters occur in a syllable. This typological universal is only applicable to final consonant clusters only. The test results do not conform with the Resolvability Principle. The Resolvability Principle claims that if a language has a consonantal sequence of length m in either initial or final position, it also has at least one continuous subsequence of length m-1 in this same position. Taiwanese[3] speakers' interlanguage data show that they can produce a consonantal sequence of 3 [spr-], but fail to produce a consonantal sequence of 2 [bl-], which violates the proposed typological universal. Thus, intrinsic universals are proposed to explain the interlanguage data in this study, i.e. the position that a consonant cluster occurs in a

[1] I am hesitating to use the word "acquisition", because this study is not a longitudinal study, and its scope is limited to the production form only. Although I think "production" is a more appropriate word to use here, however, in order to conform with the word choice by Eckman, I shall use "acquisition" instead of "production".

[2] acknowledgment to Aim for the Top University Plan, Ministry of Education, Taiwan, R.O.C. and anonymous reviewers of ROCLING2011.

[3] Taiwanese is a South-Min variety of Chinese spoken in Taiwan. This language does not allow consonant clusters.

syllable and its articulatory components all contributed to the intrinsic universals.

Keywords: structural conformity hypothesis, typological universals, second language acquisition, consonant clusters

## 1. Introduction

The acquisition of consonant clusters has been a popular issue in SLA. If a language does not allow consonant clusters, what would happen when a speaker of that language tries to acquire English consonant clusters. Eckman (1987) and Karimi (1987) have found that final obstruents devoicing, vowel insertion, and consonant deletion are common strategies employed by L2 learners.

One implicational universal has been posited by Greenberg (1978), which is possession of property *Pi* implies possession of *Pj*--but not vice versa. Lass (1989:131) made a comment on implicational universals. He said:

> *It is uncertain whether a large and interesting set of such statements can be made; steps have been taken, but we're nowhere near knowing yet if the goal is attainable.*

Lass (1989:132) further pointed out that the implicational universals were usually under the heading of 'markedness'. He listed several criteria for defining a marked segment. They are: (i) less common cross-linguistically than its unmarked counterpart; (ii) tends not to appear in positions of neutralization; (iii) generally has lower text-frequency; (iv) is later in appearing during language-acquisition, (v) tends to undergo phonemic merger; (vi) tends to be less stable historically; (vii) tends to imply the existence of its unmarked counterpart.

Despite the dispute about implicational universals, Eckman (1991) posited a Structural Conformity Hypothesis, attempting to explain the difficulty and the developmental sequence in acquiring English consonant clusters. He proposed that universal generalizations of primary language also apply to interlanguage. He strived to test two implicational universals in interlanguage. One was the *Fricative-Stop Principle*; the other was the *Resolvability Principle*.

In this study, three problems regarding Eckman's Structural Conformity Hypothesis were identified. One is that Eckman overlooked one important variable, the voicing of a consonant cluster. All the words he used for his study were consonant clusters of voiceless obstruents. He did not provide an explanation for why he chose to do so. Our study indicates that clusters of voiced obstruents acquire later than their voiceless counterparts, because voiced obstruents are more difficult to produce intrinsically. The oral constriction impedes the airflow required by voicing

(Stampe 1979:7), that can explain the devoicing phenomena observed in native English speakers' word-initial and word-final voiced consonant and consonant clusters.[4]

The second problem was how Eckman determined the presence or absence of a target consonant cluster. The criteria for the presence of a consonant cluster was 80% of occurrence of that consonant cluster. However, Eckman did not go into details on how he determine the occurrence of a consonant cluster. How did he determine if a consonant is deleted or pronounced unreleased? To what extend would he consider an epenthetic vowel present? Edge (1991) studied the production of word-final voiced obstruents in English by L1 speakers of Japanese and Cantonese,. He found that the voicing-devoicing decision was the most troublesome. If both consonant deletion and vowel epenthesis were both found in native English speakers' speech, how would he define a target form? All the questions mentioned above may affect the choice of a target form, and the judgment call of the presence or absence of a consonant cluster.

The third problem was the applicability of implicational universals as a prediction of second language behavior. Because implicational universals are structurally based, while second language behavior has more than one attribute.

## 2. Application of Implicational Universals

Not all implicational universals can be applied directly to predict second language behavior. Implicational universals which are phonetically motivated can better explain the interlanguage phenomena. Our study is to bring up this issue by comparing our test result with the two implicational universals proposed by Eckman. Here are two intrinsic universals (phonetically motivated principles) proposed in this study.

(i) Word-initial consonant clusters are easier to acquire than word-final consonant clusters. This principle is motivated by the fact that word-initial consonant clusters can be released through the following nucleus (vowel), while word-final consonant clusters cannot.

(ii) Clusters of voiced obstruents acquire later than the voiceless consonant clusters, because their oral constriction impedes the airflow required by voicing. Therefore, they are more difficult to produce than voiceless consonant clusters.

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[4] Ladefoged (1982) stated that English word-final voiced consonants are partially voiceless. Lisker & Abramson (1964) also pointed out that English initial voiced stops should be transcribed as voiceless unaspirated.

## 3. Method

### Subjects

The subjects for this study were ten Taiwanese speakers. Two native American English speakers, mean age 25, served as the control group. Appendix 1 gives a profile of the participants. The Taiwanese speakers, mean age 30.6, all had six years of high-school English and college English in Taiwan. Their English speaking proficiency level ranged from intermediate to advanced. Eight of them had extensive exposure to English speaking environment, 5.9 years on the average.

### Materials and Procedures

In order to compare Taiwanese interlanguage data with the native English speakers' pronunciation under the same context, a sheet of words which contains English initial and final consonant clusters were listed (Appendix 2). Each word was read twice by a subject. Initial consonant clusters test items are listed in Table 1. Final consonant clusters test items are listed in Table 2. Phonetic environment, familiarity and frequency of the test words were taken into consideration, but not strictly controlled.

**Table1. Initial Consonant Cluster Test Items**

| bl-(1) blue | br-(1) bring | kl-(2) class climb | kr-(2) cream crisp | tr-(1) tree | dr-(2) dreams dry | dw-(1) dwarf | fl-(1) flag | fr-(1) friend | gl-(1) glass | gr-(2) grow groups | pl-(1) play | pr-(1) pray |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| qw-(2) question quilt | sk-(1) sky | sl-(1) slow | sp-(1) spilt | ʃr-(1) shrimp | θ r-(1) three | skr-(1) scream | sp-(1) speak | spr-(1) spring | st-(3) stamped stand stands | str-(1) street | tw-(1) twenty | N/A |

**Table2. Final Consonant Cluster Test Items**

| -rm (1) arm | -nt (1) aunt | -rn (1) barn | -gd (1) begged | -rf (1) dwarf | -kt (1) fact | -nd (2) friend stand | -dz (1) beds | -lp (1) help | -rp (1) harp | -zd (1) buzzed | -rb (1) orb | -md (1) seemed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -mz (1) dreams | -st (1) last | -nz (1) pens | - ŋdʒ (1) orange | -rk (1) park | -sk (1) risk | -ndz (1) stands | -rd (1) hard | -lpt (1) helped | -ps (2) lips groups | -lθ (1) health | -bz (1) Bob's | -sp(1) crisp |

| -rmz (1) arms | -nst (1) balanced | -rnz (1) barns | -ndʒd (1) changed | -rks (1) parks | -ks (1) six | -ʃt (1) pushed | -rt (1) short | -lt (2) quilt spilt | -rps (1) harps | -lz (1) walls | -rbz (1) orbs | -ŋk (1) thank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -mp (1) Jump shrimp | -nts (1) aunts | -ts (2) seats sits | -rv (1) carve | -kts (1) collects | -kst (1) next | -ft (1) shift | -rz (1) years | -lvd (1) solved | -nθ (1) month | -lb (1) bulb | -gz (1) legs | -ŋz (1) sings |
| -mpt (2) jumped stamped | -mps (1) jumps | -rnt (1) arn't | -rvd (1) carved | -rkt (1) parked | -sts (1) beasts | -tʃt (1) watched | -rts (1) hearts | -ld (1) world | -nθ s (1) months | -lf (1) wolf | -bd (1) webbed | -ŋks (1) thanks |

Ten native speakers of Taiwanese were instructed to read the word list. Two native American English speakers served as the control group. Subjects were instructed to read each word twice, as naturally as possible, i.e. not to make an extra effort to adjust their accent. Subjects were given time to skim through the word list. Their pronunciation was recorded with a AIWA stereo cassette recorder (Model No. HS-J303) with an external microphone.

## 4. Analysis

The recordings were used as the input for the acoustic analysis[5] to verify the transcription. With the visual information of spectrogram, the researcher was able to make a more consistent and objective judgment call on the voicing distinction.[6] It also helped to identify if an epenthetic vowel was present.[7]

A list of subcategorization tags of position in a syllable and consonant clusters types can be found in Appendix 3. For example, **i** stands for word-initial, **f** stands for word-final, **pf** stands for a voiceless stop followed by a voiceless fricative, **bb** stands for a voiced stop followed by a voiced stop, etc.

There were four variables involving in the analysis of the consonant clusters: the position of the consonant cluster in a word, the number of consonants in a cluster, the voicing and the manners of articulation in a consonant cluster, and the categorization of the consonant cluster in terms of target-like and native-like[8]

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[5] The spectrograms were done on the DSP Sono-Graph: model 5500

[6] If a segment is voiced, a low frequency dark stripe will show on the spectrogram.

[7] If there exists an epenthetic vowel, the vowel formants can be detected on the spectrogram.

[8] Target-like refers to the form which is predicted by the pronunciation rules of standard English. Native-like refers to the form which is deviant from the pronunciation rules of standard English, yet conforms to the way the two native speakers of English pronounced.

dimensions. For instance, if *-rnt* is pronounced as [rnt], it will be categorized as f|3|lnp|t, f satnds for word-final, 3 stands for a consonant cluster of three, lnp indicates that this is a sequence of a liquid + a nasal + a voiceless stop, and 't' stands for target-like forms. Appendix 3 lists all the subcategorization tags used in the current study.

If the two tokens were not pronounced in the same category by a subject, they would be marked by a question mark "?". Each consonant cluster was classified into one of the following four categories: target (t), non-target (n), target-but-non-native (N), and non-target-but-native (T). A target form is predicted by the pronunciation rules of Standard English. For example, the *-s* in *arms* should be pronounced as [z]. However, both the native English speakers pronounced it as [s]. Therefore, [z] will be considered target-but-non-native (N), while [s] will be considered as non-target-but-native (T). Non-target forms are those which involve deletion, devoicing, epenthesis, or other strategies that adult native English speakers do not usually use. For example, r --> w is a process of increasing sonority, i.e. making r less consonant like and easier to produce; therefore, r --> w, w is considered a non-target form.

## 5. Interrater Reliability

Two Taiwanese subjects' recordings were used for comparing interrater reliability. The researcher had one native English speaker and one Taiwanese speaker as raters of the researcher's transcriptions. This is to see how difference in rater's language background would effect the interrater reliability. Raters were told to circle one transcription that he or she agreed upon. If what they hear on the tape does not match either one of the given transcriptions, they can write down their own transcription in the blank space. We found the agreement rate between the researcher and the native English speaker was 91% for subject 1's interlanguage data and 73% for subject 2's interlanguage data. The agreement rates between the researcher and the Taiwanese rater were 85% and 67% respectively, and the agreement rates between the two raters were 85% and 71%. The difference in the interrater reliability shown in the data may be correlated with the accuracy in the two subjects' interlangauge pronunciation. Subject 1's pronunciation had higher accuracy rate.

## 6. Instrumentation

I used CHILDES[9] (Child Language Data Exchange System) to process the

[9] CHILDES is a software package originally designed to analyze L1 acquisition data. Here I am applying it to analyze L2 data.

subcategorized data. Each word was represented by three tiers in CHILDES. Each begins with a percent sign %. The first tier listed the code for the subject and the target word. For example, the following representation tells us that the speaker is PSZ, and the target word is *arm*.

%PSZ: arm

The second tier is the phonetic tier, which listed the expected target form and the actual pronunciation. For example, the following representation tells us that "pho" stands for the phonetic tier, rm is the expected target form, and the actual pronunciation was [rm].

%pho: rm=rm

The third tier is the quality tier, which coded the four variables previously mentioned. For example, the following representation tells us that "qua" stands for the quality tier, 'f' satnds for word-final, 3 stands for a consonant cluster of three, 'ln' indicates that this is a sequence of a liquid + a nasal, and 't' stands for a native-like target form.

%qua: f|2|ln|t

The format of each entry in CHILDES would look like the following:

%PSZ: arm

%pho: rm=rm

%qua: f|2|ln|t

## 7. Results

Graph 1 shows that the target-like percentage is significantly higher at the word-initial position than at the word-final position. This is true for all ten Taiwanese subjects' interlanguage data (Appendix 4). It is also true for a consonant cluster of two or three segments (see Table 3).

Graph 1. **target-like consonant clusters of word-initial and word-final**

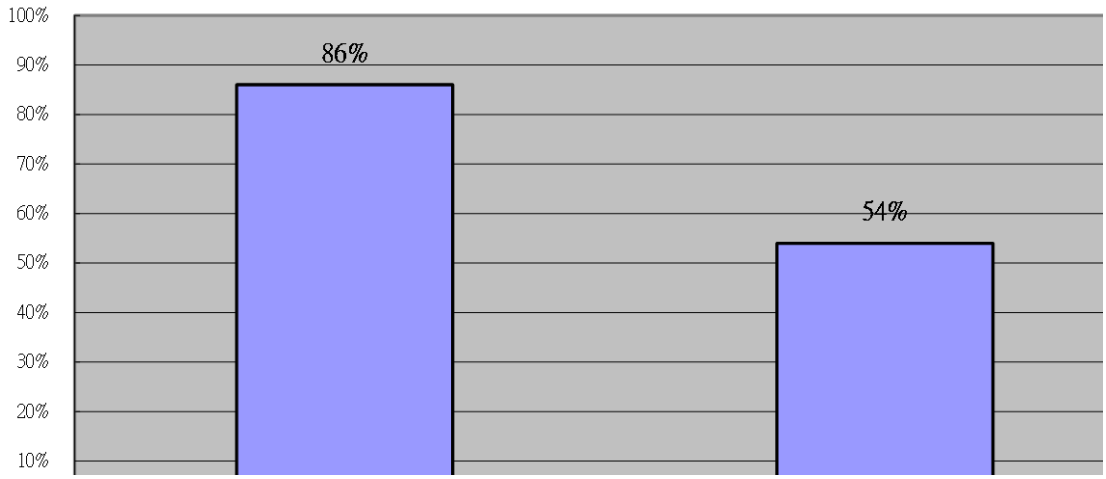

Table 3. Percentage of target-like consonant clusters in terms of number of consonants

| | 2 consonants in a cluster | 3 consonants in a cluster |
|---|---|---|
| initial | 86% | 85% |
| final | 61% | 42% |

Graph 2 shows that the target-like percentage is significantly lower for consonant clusters of voiced segments than for those of voiceless segments. This is true for all interlanguage data (Appendix 5). It is also true for a consonant cluster of two or three segments (see Table 3).

**Graph 2.** target-like consonant clusters of voiced vs. voiceless segments

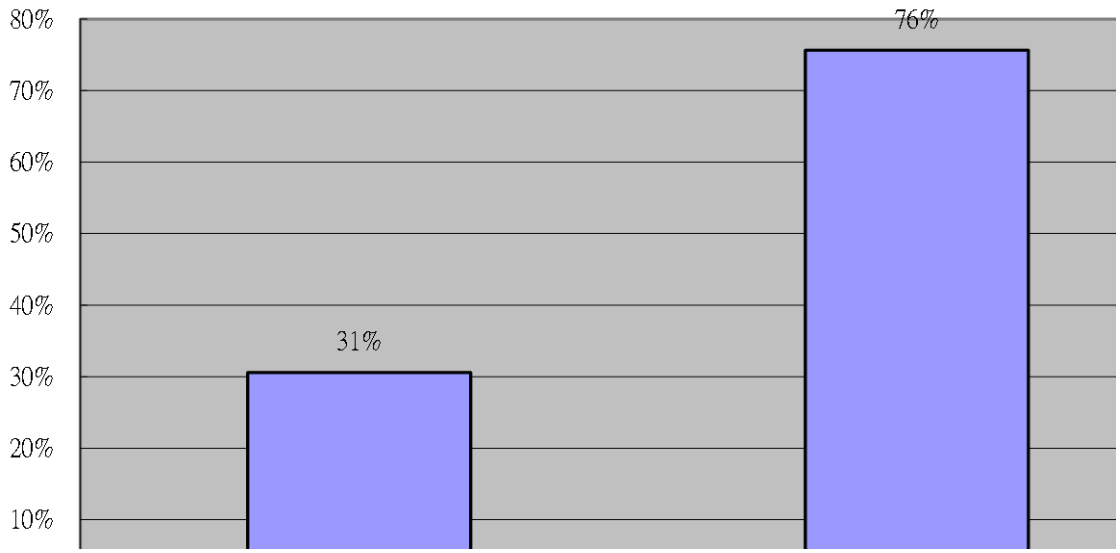


Table 4 shows that the target-like percentage is consistently higher at word-initial position. Word-final 2 consonants in a cluster achieves higher percentage of target-like forms than 3 consonants in a cluster. However, four subjects does not conform to the Resolvability Principle at word-initial position, i.e., 2 consonants in a cluster does not necessarily achieves the higher percentage of target-like forms than 3 consonants in a cluster for all subjects.

Table 4. Percentage of target-like consonant clusters in terms of position and number

| | i2 | i3 | f2 | f3 | i | f |
|---|---|---|---|---|---|---|
| PSZ | 92% | 100% | 83% | 71% | 93% | 79% |
| CSH | 96% | 75% | 75% | 71% | 93% | 74% |
| PXJ | 92% | 75% | 56% | 50% | 90% | 54% |
| KJR | 80% | 75% | 46% | 33% | 79% | 42% |
| CJL | 96% | 100% | 79% | 75% | 97% | 78% |
| HZX | 80% | 100% | 71% | 54% | 83% | 65% |
| ZSY | 80% | 50% | 56% | 21% | 76% | 44% |

| | | | | | | |
|---|---|---|---|---|---|---|
| RMY | 84% | 100% | 42% | 8% | 86% | 31% |
| LX | 76% | 75% | 54% | 17% | 76% | 42% |
| WMQ | 84% | 100% | 46% | 17% | 86% | 36% |
| avg | 86% | 85% | 61% | 42% | 86% | 54% |

i2=initial consonant cluster of 2; i3= initial consonant cluster of 3; f2= final consonant cluster of 2; f3=final consonant cluster of 3; i=initial consonant; f=final consonant

Table 5 shows that the initial and final voiced consonant clusters may be pronounced devoiced even by native speakers. The target-like percentage is consistently higher for voiceless counterpart consonant clusters in both word-initial and word-final positions. The data in Table 5 suggest an intrinsic universal favor voiceless consonant clusters.

Table 5. Percentage of native-like consonant clusters in terms of position and number

trg = target-like
ntv = native-like

| initial | Tw(trg) | Eng(trg) | Tw(ntv) | Eng(ntv) |
|---|---|---|---|---|
| bl- | 68% | 75% | 82% | 100% |
| pl- | 77% | 100% | 77% | 100% |
| bw- | 90% | 100% | 90% | 100% |
| pw- | 100% | 100% | 100% | 100% |
| **final** | **Tw(trg)** | **Eng(trg)** | **Tw(ntv)** | **Eng(ntv)** |
| -bb | 10% | 75% | 15% | 100% |
| -pp | 90% | 100% | 90% | 100% |
| -bv | 27% | 33% | 27% | 100% |
| -pf | 84% | 100% | 84% | 100% |
| -vb | 20% | 50% | 40% | 100% |
| -fp | 84% | 100% | 84% | 100% |
| -lbv | 10% | 0% | 0% | 100% |
| -lpf | 37% | 100% | 37% | 100% |
| -lb | 13% | 67% | 20% | 100% |
| -lp | 50% | 100% | 50% | 100% |
| -lv | 15% | 50% | 20% | 100% |
| -lf | 35% | 63% | 35% | 100% |
| -nG | 40% | 0% | 90% | 100% |
| -nC | 100% | 100% | 100% | 100% |
| -nb | 43% | 100% | 43% | 100% |

| | | | | |
|---|---|---|---|---|
| -np | 80% | 100% | 80% | 100% |
| -nv | 0% | 0% | 77% | 100% |
| -nf | 95% | 100% | 95% | 100% |
| -npf | 63% | 100% | 63% | 100% |
| -npp | 55% | 100% | 55% | 100% |

Table 6 and Table 7 were results of the partial replication and extension of Eckman's two implicational universals. Table 6 shows that 3 out of 10 subjects violated Eckman's Fricative-Stop Principle, which says if a language has at least one final consonant sequence consisting of stop + stop, it also has at least one final sequence consisting of fricative + stop.

Table 6. Interlanguage Varification Result for Eckman's Fricative-Stop Principle

+ = presence of a consonant cluster
- = absence of a consonant cluster
N = presence of a native-like but non-target consonant cluster
? = uncertain

| | PSZ | CSH | PXJ | KJR | CJL | HZX | ZSY | RMY | LX | WMQ |
|---|---|---|---|---|---|---|---|---|---|---|
| -kt | + | + | + | + | + | + | + | - | + | + |
| -sp | + | + | + | + | + | + | + | - | - | + |
| -st | + | + | + | + | + | + | - | + | ? | + |
| -sht | + | + | + | + | + | + | + | + | + | + |
| -sk | + | + | + | + | + | + | - | + | ? | + |
| -ft | + | + | + | + | + | - | + | + | - | + |
| -gd | - | + | + | - | - | - | - | - | - | - |
| -bd | N | - | - | - | - | - | - | - | - | - |
| -zd | - | N | N | - | + | - | - | + | - | - |
| FS | for | for | for | for | for | against | against | for | against | for |

Table 7 shows that 14 out of 230 tokens (6%) clearly violated the Resolvability Principle, which says if a language has a consonantal sequence of length m in either initial or final position, it also has at least one continuous subsequence of length m-1 in this same position.

Table 7. Interlanguage Varification Result for Eckman's Resolvability Principle

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| + = for Resolvability Principle 90% | | | | | | | | | | |
| - = against Resolvability Principle 6% | | | | | | | | | | |
| ? = uncertain 4% | | | | | | | | | | |
| | PSZ | CSH | PXJ | KJR | CJL | HZX | ZSY | RMY | LX | WMQ |
| -rnt | + | + | + | + | + | + | + | + | + | ? |
| -rmz | + | + | + | + | ? | + | + | + | + | + |
| -nts | + | + | ? | - | + | ? | + | + | + | + |
| -nst | + | + | + | + | + | + | + | + | + | + |
| -rnz | + | + | - | - | + | + | + | + | + | + |
| -sts | + | + | ? | ? | + | + | + | + | + | + |
| -rvd | + | + | + | + | + | + | + | + | + | + |
| -kts | + | + | ? | ? | + | + | + | + | + | + |
| -rps | + | + | + | + | + | + | + | + | + | + |
| -rts | + | - | - | + | + | + | + | + | + | + |
| -lpt | + | + | + | + | + | + | + | + | + | + |
| -mps | + | + | + | + | + | + | + | + | + | + |
| -kst | + | + | + | + | + | + | + | + | + | + |
| -rbz | + | + | + | + | + | + | + | + | + | + |
| -rkt | + | + | + | + | + | + | + | + | + | + |
| -rks | + | + | + | + | + | + | + | + | + | + |
| -ndz | + | + | + | - | ? | + | + | + | + | + |
| -ngks | + | + | + | + | + | + | + | + | + | - |
| -mpt | + | + | + | + | + | + | + | + | + | ? |
| spl- | + | + | - | - | + | + | + | + | + | + |
| str- | + | + | - | - | + | + | + | + | + | + |
| spr- | + | + | + | + | + | - | + | + | + | - |
| skr- | + | + | + | + | + | - | + | + | + | + |

## 8. Discussion

In this section, two main points will be discussed: (a) the applicability of implicational universals; (b) intrinsic universals (phonetically motivated) can best explained the interlanguage phenomena.

The difference between typological universals and intrinsic universals is that we can always find counterexamples to the typological universals, but not to intrinsic universals. Not only interlanguage data but also first language data would conform

to intrinsic universals. Typological universals are general statements about the tendency observed in documented language structures. People can always find counterexamples to typological universals no matter in primary language or in interlanguage. As the results shown in the study, we do find counterexamples to Eckman's principles. In fact, Eckman also observed counterexamples in his own study. However, he tried to explain the counterexamples with the lack of enough tokens to evaluate the result. However, we should not ignore counterexamples simply because the number is small. On the contrary, intrinsic universals can be explained by the phonetic laws of natural language, such as ease of production. There will be no exception to the intrinsic universals.

Another important issue relating to the proposed intrinsic universals is that second language researchers were trying to employ the typological universals to explain the phenomena observed in interlanguage data. I will quote Lass's (1989: 132-33) comment on this particular issue. He says:

> *It is debatable, however, if these observations can be pushed much further, i.e. given a non-formal, non-statistical interpretation, and used as the basis for an explanatory (predictive) theory. ... But it is not clear that the predictive power of any form of markedness theory is enough to make it interesting--as anything but a set of inductive generalizations about the distributions of properties in the world's languages. In particular there seems to be no good way to accounting for the 'failures' of markedness predictions*.

## 9. Conclusion

Eckman's (1991) Structural Conformity Hypothesis would have been a valid hypothesis, if he had applied intrinsic universals rather than typological universals. Position in a word and the voicing quality turn out to be the critical factors for the acquisition of consonant clusters rather than the number of a cluster sequence nor the stop-fricative difference.

The results of the current study not only sort out the intrinsic factors that is essential to the acquisition of consonant clusters, but also raise an important issue for SLA, i.e., what can be used as an explanatory theory for SLA? SLA is considered as an applied science, which means it is heavily dependent upon other disciplines of science. This study suggests that the L2 acquisition should be based on cognitively-induced intrinsic universals rather than structurally-based typological universals.

**Appendix 1. Subject profile**

| Name | NL | Age | Sex | Exposure to English-Speaking Env. |
|---|---|---|---|---|
| JY | Eng | 28 | M | Native English speaker |
| DA | Eng | 24 | F | Native English speaker |
| PSZ | Tw | 25 | F | *1 year* |
| *CSH* | *Tw* | *34* | *F* | *2.5 years* |
| *PXJ* | *Tw* | *26* | *F* | *5 years* |
| *KJR* | *Tw* | *26* | *M* | *9 months* |
| *CJL* | *Tw* | *25* | *F* | *2 years* |
| *HZX* | *Tw* | *43* | *F* | *20 years* |
| *ZSY* | *Tw* | *21* | *F* | *None (reside in Taiwan)* |
| *RMY* | *Tw* | *32* | *M* | *6 years* |
| *LX* | *Tw* | *51* | *F* | *10 years* |
| *WMQ* | *Tw* | *23* | *M* | *None (reside in Taiwan)* |

**Appendix 2. A Word List of consonant clusters**

| | | | |
|---|---|---|---|
| accidental | day | magazine | spilt |
| aren't | dish | month | six |
| arm | dreams | months | sky |
| arms | dry | necessarily | slow |
| aunt | during | next | solved |
| aunts | dwarf | no | speak |
| balanced | fact | orange | spring |
| barn | flag | orb | stamped |
| barns | friend | orbs | stand |
| beasts | garage | park | stands |
| beautiful | give | parked | street |
| beds | glass | parks | television |
| begged | groups | peas | thank |
| blue | grow | pens | thanks |
| Bob's | hard | play | this |
| bring | harp | pray | three |
| bulb | harps | pure | tree |
| butter | health | pushed | tune |
| buzzed | hearts | question | twenty |
| carve | help | quilt | vacation |

| | | | |
|---|---|---|---|
| carved | helped | risk | walls |
| chair | inch | scream | watched |
| changed | international | seats | webbed |
| class | jump | seemed | why |
| climb | jumped | shift | with |
| collects | jumps | short | wolf |
| comparative | language | shrimp | world |
| cream | last | since | years |
| crisp | legs | sings | yes |
| cute | lips | sits | zero |

## Appendix 3. List of Subcategorization Tags

i = word-initial
f = word-final
2 = a consonant cluster of two
3 = a consonant cluster of three
t = target
n = non-target
N = non-target but native-like
T = target but non-native-like
? = the utterances can not be classified into one category
Cp = voiceless affricate + voiceless stop
bb = voiced stop + voiced stop
bl = voiced stop + liquid
bv = voiced stop + voiced fricative
bw = voiced stop + [w]
fl = voiceless fricative + liquid
fpf = voiceless fricative + voiceless stop + voiceless fricative
fpl = voiceless fricative + voiceless stop + liquid
fp = voiceless fricative + voiceless stop
lbv = liquid + voiced stop + voiced fricative
lb = liquid + voiced stop
lf = liquid + voiceless fricative
llb = liquid + liquid + voiced stop
lnp = liquid + nasal + voiceless stop
lnv = liquid + nasal + voiced fricative
ln = liquid + nasal

lpf = liquid + voiceless stop + voiceless fricative
lpp = liquid + voiceless stop + voiceless stop
lp = liquid + voiceless stop
lvb = liquid + voiced fricative + voiced stop
lv = liquid + voiced fricative
nC = nasal + voiceless affricate
nGb = nasal + voiced affricate + voiced stop
nG = nasal + voiced affricate
nbv = nasal + voiced stop + voiced fricative
nb = nasal + voiced stop
nff = nasal + voiceless fricative + voiceless fricative
nfp = nasal + voiceless fricative + voiceless stop
nf = nasal + voiceless fricative
npf = nasal + voiceless stop + voiceless fricative
npp = nasal + voiceless stop + voiceless stop
np = nasal + voiceless stop
nv = nasal + voiced fricative
pfp = voiceless stop + voiceless fricative + voiceless stop
pf = voiceless stop + voiceless fricative
pl = voiceless stop + liquid
ppf = voiceless stop + voiceless stop + voiceless fricative
pp = voiceless stop + voiceless stop
pw = voiceless stop + [w]
vb = voiced fricative + voiced stop

**Appendix 4. Percentage of target-like consonant clusters of the ten subjects**

| | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| initial | 93% | 93% | 90% | 79% | 97% | 83% | 76% | 86% | 76% | 86% | 86% |
| final | 79% | 74% | 54% | 42% | 78% | 65% | 44% | 31% | 42% | 36% | 54% |

Appendix 5. **Percentage of target-like consonant clusters in terms of voiced and voiceless components**

| | bl- | bw- | -bb | -bv | -vb | -lbv | -lb | -lv | -nG | -nb | -nv | average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| voiced | 68% | 90% | 10% | 27% | 20% | 10% | 13% | 15% | 40% | 43% | 0% | 31% |
| voiceless | 77% | 100% | 90% | 84% | 84% | 37% | 50% | 35% | 100% | 80% | 95% | 76% |

References


[1] Croft, William. 2003. 2nd ed. Typology and Universals. New York: Cambridge University Press.

[2] Eckman, Fred R. 1991. The structural conformity hypothesis and the acquisition of consonant clusters in the interlanguage of ESL learners. SSLA 13.23-41.

[3] Eckman, Fred R. 1987. The reduction of word-final consonant clusters in interlanguage. Sound patterns in second language acquisition, ed. by Allan James and Jonathan Leather,143-62. Dordrecht: Foris.

[4] Karimi, S. 1987. Farsi speakers and the initial consonant cluster in English. Interlanguage phonology, ed. by Georgette Ioup and Steven H. Weinberger,305-18. Cambridge: Newbury House Publishers.

[5] Greenberg, Joseph, H. 1978. Universals of Human Language. California: Stanford University Press.

[6] Lass, Roger. 1989. Phonology: An introduction to basic concepts. Cambridge: Cambridge University Press.

[7] Stampe, David. 1979. A dissertation on natural phonology. New York: Garland Publishing, Inc.

[8] Ladefoged, Peter. 1982. A course in phonetics. 2nd ed. Los Angeles: Harcourt Brace Jovanovich, Inc.

[9] Lisker, Leigh, and Arthur S. Abramson. 1964. A cross-language study of voicing in initial stops: acoustical measurements. Word 20.384-422.

[10] Carlisle Robert S. 2001. Syllable structure universals and second language acquisition. International Journal of English Studies 1.1-19.

[11] Edge, Beverly A. 1991. The production of word-final voiced obstruents in English by L1 speakers of Japanese and Cantonese. SSLA 13.377-93.

[12] Edwards, Jette G. Hansen, & Mary L. Zampini (Eds.). 2008. Phonology and second language acquisition. Philadelphia: Benjamins.

[13] Major, Roy C. 1987. The natural phonology of second language acquisition. Sound patterns in second language acquisition, ed. by Allan James and James Leather,207-24. Dordrecht: Foris.

[14] Sato, Charlene J. 1985. Task variation in interlanguage phonology. Input in second language acquisition, ed. by Susan M. Gass and Carolyn G. Madden,181-96. Rowley: Newbury House Publishers, Inc.