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AN OT ANALYSIS OF MANDARIN INTERFERENCE IN THE PRONUNCIATION OF ENGLISH OBSTRUENT-OBSTRUENT CLUSTERS*

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ABSTRACT

Considerable research has focused on the interference of the native language (L1) in second language (L2) learning, motivating the present study to look more deeply into how Mandarin interferes in the pronunciation of English obstruent-obstruent clusters by Taiwan Mandarin-speaking elementary school children. Optimality Theory is utilized to provide a formal analysis of Taiwan elementary school children's strategies for pronouncing English obstruent-obstruent clusters: schwa [ə] insertion or obstruent deletion. English syllables allow complex syllable margins, while Mandarin syllables strictly forbid obstruent clusters at syllable margins. Therefore, Taiwan elementary school children might utilize either epenthesis or the deletion of segments to deal with the pronunciation of English words with complex syllable margins. The constraint ranking proposed in the study reflects that Taiwan elementary school children's pronunciation of English obstruent-obstruent clusters shows interference from Mandarin. Utilizing the findings in the present study and the propositions contained within the Contrastive Analysis Hypothesis, the study will provide pedagogical suggestions on form-focused instruction and corrective feedback.

Key words: Optimality Theory, English consonant clusters, language interference, second language acquisition, Contrastive Analysis Hypothesis

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1. INTRODUCTION

It is well known that most second language (L2) learners of English have problems pronouncing English consonants. Consonants in the onset position or in the coda position can be problematic for the reason that there are differences between the consonant inventories of English and the L1 of the learner. For instance, some consonants in English do not occur in the learners' L1 phonology. Therefore, many studies have been conducted to investigate how L2 speakers acquire English consonants (Chan and Li 2000; Chan 2007; Edge 1991; Hansen 2001; He 2014). Edge (1991) pointed out that Japanese and Cantonese speakers frequently devoiced English word-final obstruents when pronouncing them. The same situation was found with the subjects in He's study (2014). He examined Chinese speakers' pronunciation of the English syllable final [l]. It was found that Chinese speakers had great difficulty in pronouncing the syllable final [l], and that to simplify the pronunciation, Chinese speakers utilized one of three strategies: vocalization, deletion, or retroflexion to modify the pronunciation of the syllable final [l] after different vowels (i.e., [i], [ɛ], [ɔ], or [u]).

In addition, L2 learners' production of consonant clusters seems to have attracted increasing attention in recent years. It has been found that Korean, Mandarin Chinese, Cantonese, Arab, and Thai speakers experience difficulties in pronouncing English consonant clusters (Ahmad 2011; Al-Saidat 2010; Chan and Li 2000; Hansen 2001; Hassan 2014; Long and Setter 2000; Wei and Zhou 2002). To overcome the difficulty, the Mandarin Chinese speakers in Hansen's (2001) study employed different production strategies according to the number of coda consonants: feature change for single codas, epenthesis for two-member codas, and deletion for three-member codas. Hansen further stated the related linguistic constraints involved in use of the three modifications: L1 transfer, markedness, sonority, and natural phonological processes. Among these factors, L1 transfer played quite an important role in Mandarin Chinese speakers' acquisition of English syllable codas.

Similarly, the importance of L1 interference in L2 production is also found in Kabak and Idsardi's (2007) research where Korean speakers' perception of English consonantal sequences (i.e., consonant clusters) was tested. The researchers pointed out that the perceptual epenthesis of vowels in English consonantal sequences resulted from Korean (L1) syllable structure restrictions rather than linear co-occurrence restrictions. By a phonological analysis of the types of difficulties in pronunciation encountered by Arab learners of English as a foreign language (EFL), Al-Saidat (2010) found that Arab EFL learners unconsciously inserted a vowel in the onset and coda consonant clusters, and that L1 influence was the major reason for the declusterizing of consonant clusters.

Reasonably, L1 interference in L2 learning has been the central focus of quite a few previous studies. In Dechert's (1983) and Ellis' (1997) studies, the target language learners were found to have the inclination to utilize their L1 structure when speaking or writing in their L2, and revealed the correlation that the more different the structures of the two languages are, the more frequently errors may occur in the production of the L2. The errors thus indicate interference by the L1 in the production of the L2.

Language interference is an automatic, habitual transfer of the structures of the L1 into those of the L2 (Dulay et al. 1982). Similarly, Lott (1983:256) viewed interference as "errors in the learner's use of the foreign language that can be traced back to the mother tongue". Ellis (1997:51) defined interference as "the influence that the learner's L1 exerts over the acquisition of an L2". He further explained that learners' perception of whether the pronunciation of the L1 is transferable or not governed the transfer. The stage at which learners develop their language learning governs the transfer as well. When learning an L2, learners initially construct their own rules based on their L1 knowledge. However, when they become more proficient, their interlanguage grammar will subsequently develop so as to conform more closely to that of the L2 (Selinker 1971; Seligar 1988; Ellis 1997).

A number of prior studies on second language phonology have found that L2 learners have a tendency to transfer their L1 phonological skills to their L2 phonological knowledge (Bassetti and Lu 2016). Namely, L2 learners are frequently prone to vary their pronunciation from that of native speakers due to the interference from their L1. As Rochet (1995) points out, L2 learners sense L2 sounds based on category in the L1. In Taiwan, similarly, learners' Mandarin interference has an effect on their

L2 phonological knowledge to a certain degree, especially in their pronunciation.

The researcher, on the basis of empirical knowledge, has observed the pronunciation of many elementary students in Taiwan and found that a high percentage of Mandarin-speaking students have difficulties in pronouncing English obstruent-obstruent clusters (henceforth, O-O clusters). They frequently pronounce them by inserting a schwa [ə] between the obstruents or by deleting one of the obstruents, as in the simplification strategies that the participants in Wang's study (1995) adopted. According to the findings in the previous studies (Broselow, Chen and Wang 1998; Bassetti and Lu 2016; Hansen 2001; Rochet 1995; Wang 1995), the problems in pronunciation may be attributed to learners' L1 phonological skill transfer/L1 interference, the differences in the sound systems between the two languages, markedness, sonority, inconsistency of in English sounds and spelling, natural phonological processes, teachers' models, peers' models, and so on. This study then focuses on the main subset of the issues involved: L1 interference. The likelihood is that Taiwan elementary students' (henceforth, TESs) L1 interferes in their phonological acquisition.

English syllables allow onset and coda clusters, while Mandarin syllables allow at most one consonant occurring before a glide,[j], [ɥ], or [w], in the onset position, and allow no coda other than the alveolar nasal [n], the velar nasal [ŋ], or the retroflexed [r]. Therefore, many of the learners in Taiwan, and, especially elementary school children, have a problem pronouncing English consonant clusters. To overcome the problem, most of them utilize two strategies to simplify the pronunciation of English consonant clusters: inserting a schwa [ə] between consonants or deleting one of the consonants. For instance, when O-O clusters occur at the coda position of a monosyllabic word, most TESs frequently insert [ə] after the final obstruent (i.e., best [bɛ**st**] is pronounced as [bɛ**stə**], and disk [dɪ**sk**] as [dɪ**skə**]). On the other hand, when an O-O cluster is in a heterosyllabic position — where one obstruent forms the coda of a syllable and the other forms the onset of the next syllable — of a multisyllabic word, the deletion of the preceding obstruent of the O-O cluster usually co-occurs. Thus, doctor [`dɑ**kt**ɚ] is not pronounced as [`dɑ**kət**ɚ] but as [`dɑ**t**ɚ], and September [sɛ**p**`**t**ɛmbɚ] is pronounced as [sɛ`**t**ɛmbɚ] rather than [sɛ**pə`t**ɛmbɚ]. When O-O clusters appear in the onset position, however, segments are neither inserted nor deleted, as in their pronunciation of inspire [ɪn`**sp**aɪr] and street [**st**ri:t]. Therefore, the present study aims to answer the following questions:

a. How well do Taiwan elementary students pronounce English obstruent-obstruent clusters?
b. What strategies do Taiwan elementary students use to simplify the pronunciation of English obstruent-obstruent clusters?
c. Does Mandarin interference play a major role in causing Taiwan elementary students to have difficulty in pronouncing English obstruent-obstruent clusters?

In this paper, Optimality Theory (Prince and Smolensky 1993) is applied to determine whether Mandarin interferes in the pronunciation of English O-O clusters produced by TESs. It is expected that the results of the analysis will produce feasible pedagogical advice and so contribute to further research. The remainder of this paper is organized as follows. A comparison of English with Mandarin phonology is provided in section 2. The results of an experiment to verify the researcher's observations are reported in section 3. TESs' pronunciation of English O-O clusters with data from the researcher's L2 learners is discussed in section 4. Then, Optimality Theory is drawn on to analyze Mandarin interference in TESs' pronunciation of English O-O clusters in section 5. Finally, some specific pedagogical advice and conclusions are presented in sections 6 and 7.

2. BASES OF MANDARIN AND ENGLISH PHONOLOGY

This section starts by presenting a brief outline of the phonological bases of Mandarin and English, which are relevant to the study. Section 2.3 then compares the syllable structure of Mandarin with that of English.

2.1 Mandarin Syllable Structure and Phonotactics

Mandarin is a language in which the syllables are allowed variable templates, ranging from a minimum of V to a maximum of CGVX (Lin 2007). In Mandarin, there are eight variable syllable templates that are based on permissible combinations of the four segments C, G, V, and X (Třísková 2011). They are V, CV, VX, GV, GVX, CVX, CGV, and CGVX.

Each of the four positions, C, G, V, and X, can be occupied by at most one segment. The V segment constitutes an obligatory item in a syllable, while the others, C, G, and X, are optional. The C segment, an initial consonant, combined with the G segment, an on-glide, is the only possible onset consonant cluster in Mandarin syllables. The V segment, a vowel, can constitute a syllable by itself or be combined with other segments. The X segment in the coda position can be a nasal (i.e., [n] or [ŋ]) or a retroflexed [r] (He 2014).

2.2 English Consonant Structure

Similar to Mandarin, English syllable structure also allows variable templates. However, unlike Mandarin, it allows for onset and coda consonant clusters. It can allow at most three consonants in the onset position and four consonants in the coda position. English syllable structure then permits anything from a minimum of V to a combination of (C)(C)(C)V(C)(C)(C)(C).

2.3 A Contrastive Analysis of Mandarin and English Syllable Structure

In Mandarin syllable structure, there is only one possible onset consonant cluster, CG. It should also be noted that there are no coda except [n], [ŋ], and the retroflexed [r] in Mandarin. English, on the other hand, allows both onset and coda clusters in its syllable structure. The differences between the phonological systems of Mandarin and those of English are illustrated as follows:

a. In many analyses (Chao 1968; Cheng 1973; Duanmu 2000), the Mandarin phonological system is presented as having twenty-four consonants and ten vowels, there being many different views on the number of Mandarin vowels and consonants. The English phonological system, however, consists of twenty-four consonants and twelve vowels. English and Mandarin sound inventories are presented in Table 1 to Table 4.

Table 1. Mandarin Vowels (based on Lin 2007)

i y ɨ u
ɛ ə ɚ ɤ o
a

Table 2. English Vowels (based on Giegerich 1992)

i ɪ u ʊ
ɛ ə ɚ ʌ ɝ ɔ
æ ɑ

Table 3. Mandarin Consonants (based on Lin 2007)

		labial	dental-alveolar	alveo-palatal	palatal	retroflex	velar
plosive	-asp	p	t				k
	+asp	pʰ	tʰ				kʰ
fricative		f	s	ɕ		ʂ	x
affricate	-asp		ts	tɕ		tʂ	
	+asp		tsʰ	tɕʰ		tʂʰ	
nasal		m	n				ŋ
liquid			l				
glide					j ɥ		w

Table 4. English Consonants (based on Giegerich 1992)

		bilabial	labio-dental	inter-dental	alveolar	palatal	velar	glottal
plosive	+vcd	b			d		ɡ	
	-vcd	p			t		k	
fricative	+vcd		v	ð	z	ʒ		h
	-vcd		f	θ	s	ʃ		
affricate	+vcd					tʃ		
	-vcd					dʒ		
nasal	+vcd	m			n		ŋ	
liquid/retroflex	+vcd				l/r			
glide	+vcd					J	w	

b. A comparison of the consonant patterns between the two languages shows that Mandarin and English evidently differ significantly in the place and manner of articulation. Some features, such as voicing, can be distinctive in English, but not in Mandarin. Take the pairs [p] and [b], [s] and [z], [t] and [d], and [k] and [ɡ] as examples. In English, each phoneme in these pairs can be differentiated from the other by the feature of voicing. In Mandarin, however, only the [ʐ] sound is distinct from the [ʂ] sound in voicing. That is to say, [ʐ] is the only voiced obstruent in Mandarin. The Mandarin pairs [p] and [p^h], [t] and [t^h], [k] and [k^h], [ts] and [ts^h], [tɕ] and [tɕ^h], and [tʂ] and [tʂ^h] reveal that the predominant distinction lies in aspiration**,** instead (Zhang and Yin 2009). Despite the fact that English has voicing contrast in obstruents, the distinction is neutralized in word-initial and word-final positions. English word-initial (i.e., onset segment) voiced stops tend to be phonologically devoiced, particularly voiced velars and bilabials, while word-initial voiceless stops tend to be strongly aspirated. Therefore, when English stops appear in the onset position, they are then distinguished mainly by aspiration, similar to Mandarin, rather than by voicing. Due to this very confusing tendency, and also to the realization that voicing is not a distinctive feature in Mandarin, we can thus explain why TESs often neglect the differences between voiced and voiceless sounds in English.

c. The position of Mandarin phonemes and the way in which Mandarin combines its phonemes are not the same as those of English. Mandarin has no coda except when the coda position is occupied by [n], [ŋ] or retroflexed [r] (i.e., [xwə**ŋ** lwə**ŋ**] and [tʂwə**ŋ** tɕja**n**]) whereas in English any consonant can appear in the coda position except [h], [w], and [j]. In Mandarin syllables, most consonants are followed by a vowel, whereas English can have consonant clusters in both the onset and coda positions.
d. Mandarin can have onset CG clusters, such as [**kw**o] and [**p**^{h}**j**əŋ], but consonant clusters cannot appear in the coda position.

3. EXPERIMENT TO INVESTIGATE TAIWAN ELEMENTARY STUDENTS' PRONUNCIATION OF O-O CLUSTERS

The phenomenon that the majority of TESs have difficulty in pronouncing English O-O clusters has been observed and tracked on account of the researcher's high involvement in primary English education. Furthermore, in order to overcome difficulties in pronunciation, TESs apply one of two strategies: a schwa [ə] insertion or an obstruent deletion. In addition, previous studies have shown that language learners' knowledge of their L1 will interfere in their L2 learning. Therefore, to verify the observation, the researcher conducted an experiment where the participants were asked to pronounce twenty-four English words (see Appendix A) which were relevant to the phenomena found in TESs' pronunciation. The twenty-four words were selected as the test items based upon the following criteria:

- To avoid the participants being unfamiliar with the test words so that they may have previously had no exposure to the sound combinations in the words, the researcher selected some relevant words frequently shown in TESs' posters, textbooks, and storybooks.
- To investigate the different strategies that the participants might utilize, the researcher chose words having O-O clusters in coda or onset positions.

- Words comprising more than three syllables increase the complexity of reading aloud and may cause participants to be afraid to read the words aloud. For this reason, most of the test words have only one or two syllables, and two of them are three-syllable words.

3.1 Research Setting

The experiment was conducted in an elementary school located in a city in northern Taiwan. In the school, the first and second graders have two English classes each week, while the third, fourth, fifth, and sixth graders have three.

3.2 Participants

Twenty Mandarin-speaking fourth graders (ten boys and ten girls) 10-11 years of age were recruited to participate in the experiment with consent forms signed by their parents (see Appendix B). They had started their formal English learning when they were first graders and, prior to elementary school, most of them had been informally introduced to English in kindergarten. Overall, the twenty participants had had a similar experience of learning English, but there were minor differences in their proficiency in English. All of them had an above-average grade in English. Even though these participants had been learning English for more than three years at the time of the experiment, they were still not at the level of proficiency according to their English performance in class.

3.3 Reading Instruction

The reading instruction was designed to engage the participants in an activity in which they were guided to read two storybooks aloud, *Brown Bear, Brown Bear, What Do You See?* and *From Head to Toe*, published by Henry Holt Books for Young Readers (1996) and HarperCollins Children Books (1999), respectively. All of the participants read the two storybooks written for third and fourth graders. These storybooks were selected as the reading materials based upon the following criteria:

- The two storybooks were written for elementary school students learning English as a second or foreign language in particular, so the words in the books should be core vocabulary for these participants to be able to read.
- Most of the words are one-syllable or two-syllable, and only a few of them are of more than two syllables. Therefore, the level of the difficulty of these words may match the levels of the participants' proficiency in English.

Through instruction in reading, it was expected that the participants would become more interested in English, be willing to read aloud in English, and become more sensitive to the phoneme-grapheme relationship.

3.4 Read-Aloud Test

In the read-aloud practice periods, each of the twenty participants were separately guided to read the twenty-four test words within a ten-minute period. The test words were divided into four categories: a. O-O clusters in the coda position of monosyllabic words (i.e., [bɛ**st**] and [dɪ**sk**]), b. obstruent-fricative and obstruent-affricate (O-F/A) clusters in the coda position of monosyllabic words (i.e., [kæ**ts**] and [dɔ**gz**]), c. heterosyllabic O-O clusters in multisyllabic words (i.e., [`dɑ**kt**ɚ] and [sɛ**p`t**ɛmbɚ]), and d. O-O clusters in the onset position (i.e., [**st**ri:t] and [**sp**rɪŋ]).

All of the participants were tested individually in a quiet classroom at the elementary school. To minimize the sequencing effect, the test words were presented in a randomized order on a sheet (see Appendix A). Before the test, the researcher read the instructions to each participant. The participants read the test words one by one, and their pronunciation was recorded simultaneously.

3.5 Data Collection Analysis

Following the selection of the participants, the researcher collected their pronunciations of the test words. Subsequently, the researcher transcribed their pronunciations using the International Phonetic Alphabet

(IPA). The elicited data were judged by two raters and classified into four categories — correct, epenthesis, deletion, and no pronunciation. Table *5* illustrates the results of the experiment.

Table 5. TESs' error types of O-O clusters

	Coda O-O in monosyllabic words (n=120)	Coda O-F/A in monosyllabic words (n=120)	Heterosyllabic O-O in multisyllabic words (n=120)	O-O in onset position (n=120)
Correct	23.3%(28)	67.5%(81)	19.2%(23)	78.3%(94)
Epenthesis	69.2%(83)	20.8%(25)	4.2%(5)	6.7%(8)
Deletion	7.5%(9)	11.7%(14)	74.1%(89)	5%(6)
No pronunciation	0%(0)	0%(0)	2.5%(3)	10%(12)

Note: 1. O-O means obstruent-obstruent clusters.
2. O-F/A means obstruent-fricative/affricate clusters.

The visual schematization of the researcher's observations is displayed in Table 5, each category of which we will discuss in turn. Most of the participants in the experiment employed [ə] epenthesis to transform English O-O clusters in the coda position of monosyllabic words to structures that conform to the Mandarin preferential size of a minimal word: two syllables (i.e., 69.2% used [ə] epenthesis in the monosyllabic words with O-O clusters). Participants' use of word-final [ə] insertion in monosyllabic words coincides with the findings in Wang's (1995) study. Wang argued that the choice of [ə] insertion was due to the Mandarin preference for disyllabic words, and thus, with the insertion, the output is then a disyllabic word.

However, epenthesis was not favored in coda O-F/A clusters despite the fact that the words were monosyllabic. Table 5 shows that 67.5% of the pronunciations of the O-F/A clusters in the coda position of monosyllabic words were correct: no insertions or deletions were made in the pronunciation. This data also conformed to the researcher's previous observation.

Obstruent deletion was the preferred strategy in multisyllabic words, as shown in 74.1% of pronunciations using deletion in multisyllabic words with heterosyllabic O-O clusters. In multisyllabic words, there is no need to insert [ə] to produce a disyllabic output. Participants frequently deleted the preceding obstruent because most of the preceding obstruents formed the coda of a syllable, while the succeeding obstruent formed an onset. The motivation for the use of the deletion strategy in multisyllabic words is to transform an impermissible syllable structure in Mandarin to one that is permissible in both Mandarin and English, such as [`dɑktɚ] (Wang 1995). [`dɑ**k**tɚ] has [k] in a coda position, but in Mandarin, [k] is an illicit coda. Therefore, as the participants were under no necessity to create another syllable to fulfill their L1 preference for disyllabic words, they deleted the coda segment as it is illegal in Mandarin.

As for onset O-O clusters, 78.3% of the pronunciation of these clusters was correct. Namely, no schwa insertion or obstruent deletion were produced in most of the participants' pronunciation. This result coincides with Mandarin syllable structure which allows for an onset CG cluster. Thus, the TESs had less difficulty in pronouncing English onset O-O clusters than in pronouncing them in other positions. However, the accuracy of 78.3% shows that the TESs still had some difficulty in pronouncing O-O clusters in the onset position so it can be inferred that they perceived a difference in the syllable structures of the two languages.

4. TAIWAN ELEMENTARY STUDENTS' PRONUNCIATION OF ENGLISH O-O CLUSTERS

From the elicited data, it was found that a high percentage of the TESs had trouble pronouncing English obstruent clusters which involve two true consonants. In addition to error rate, error types were further investigated. Two strategies were found: insertion and deletion.

4.1 [ə] Insertion after Final Obstruent in Monosyllabic Words

When pronouncing English O-O clusters in the coda position of monosyllabic words, the TESs frequently inserted [ə] after the final obstruent. However, [ə] epenthesis was not produced in the phonological environment where the final consonant of the monosyllabic word was a fricative or an affricate. That means [ə] insertion only occurs when the word-final consonant is an oral stop. Examples of the TESs' pronunciation of word-final O-O clusters in monosyllabic words are given below:

(1) Inserting a Schwa [ə] after the Final Oral Stop

[bɛst]	→ [bɛst**ə**]	'best'	[pɪtʃt]	→ [pɪtʃt**ə**]	'pitched'
[dɛsk]	→ [dɛsk**ə**]	'desk'	[wɑʃt]	→ [wɑʃt**ə**]	'washed'
[tægd]	→ [tægd**ə**]	'tagged'	[slɛpt]	→ [slɛpt**ə**]	'slept'
[bɪbd]	→ [bɪbd**ə**]	'bibbed'	[læ ft]	→ [læ ft**ə**]	'laughed'
[lɛft]	→ [lɛft**ə**]	'left'	[kræ ft]	→ [kræ ft**ə**]	'craft'

(2) No Insertion after the Final Fricative or Affricate

[kæts]	→ [kæts]	'cats'	[mɪks]	→ [mɪks]	'mix'
[dɔgz]	→ [dɔgz]	'dogs'	[li:vz]	→ [li:vz]	'leaves'

4.2 Deletion of the Preceding Obstruent of O-O Clusters in Multisyllabic Words

When an English O-O cluster occurs in the heterosyllabic position of a multisyllabic word, the TESs frequently deleted one of the obstruents instead of inserting [ə]. Moreover, their obstruent deletion did not affect the succeeding obstruent, but the preceding one. The pronunciation is exemplified below:

(3) The Deletion of the Preceding Obstruent of O-O Clusters in Multisyllabic Words

[`dɑ**k**tɚ]	→ [`dɑtɚ]	'doctor'	[`dɪ**k**ʃən͵ɛrɪ]	→ [`dɪʃən͵ɛrɪ]	'dictionary'
[ɑ**k**`toubɚ]	→ [ɑ`toubɚ]	'October'	[`pɪ**k**tʃɚ]	→ [`pɪtʃɚ]	'picture'
[sɛ**p**`tɛmbɚ]	→ [sɛ`tɛmbɚ]	'September'	[`noʊ**t**͵bʊk]	→ [`noʊ͵bʊk]	'notebook'
[`pɑ**p**͵kɔrn]	→ [`pɑ͵kɔrn]	'popcorn'	[`bʊ**k**͵bæg]	→ [`bʊ͵bæg]	'book bag'
[`lɪ**p**͵stɪk]	→ [`lɪ͵stɪk]	'lipstick'	[`frɛn**d**ʃɪp]	→ [`frɛn͵ʃɪp]	'friendship'

4.3 No Insertion or Deletion in Onset O-O Clusters

The strategy that the TESs tried in order to deal with the pronunciation of O-O clusters in the onset position was neither insertion nor deletion of any segment. When pronouncing O-O clusters in the onset position, they did not use any strategy to repair the pronunciation, as exemplified below:

(4) No Insertion or Deletion of Any Segment

[ɪn`spaɪr]→[ɪn`spaɪr]	'inspire'	[sprɪŋ] →[sprɪŋ]	'spring'
[stri:t] →[stri:t]	'street'	[mɪ`steɪk]→[mɪ`steɪk]	'mistake'
[`skɪnɚ]→[`skɪnɚ]	'skinner'	[dɪ`spleɪ] →[dɪ`spleɪ]	'display'

5. AN OT ANALYSIS

In this section, the researcher utilizes Optimality Theory (Prince and Smolensky 1993, 2004; McCarthy 2008) to analyze how TESs' pronunciation of English O-O clusters is evidence of an interaction in the constraints. The conformity to and adaptation of Mandarin phonology contribute to the arrangement of the constraint rankings.

As shown in the third and fourth sections above, the TESs adopted two strategies when pronouncing English O-O clusters. The strategies they utilized to simplify the pronunciation depended on the phonological environment in which the O-O clusters occurred. Thus, section 5.1 discusses the fundamental constraints adopted from Mandarin syllable structure as evidenced in the TESs' pronunciation. The interaction of the constraints to form a constraint ranking is discussed and presented in section 5.2.

5.1 Basic Constraints

In Mandarin syllables, the markedness constraints, NOCODA and CODACONDITION are relevant restrictions on the coda position.

(5) NOCODA: No consonant is allowed in coda position.

(6) CODACONDITION: Syllables must have no coda, except [n], [ŋ] or retroflexed [r].

NOCODA is formulated to mark the contrast between English syllables and Mandarin ones. Mandarin syllables must have no coda with the exceptions of [n], [ŋ] or retroflexed [r]. Therefore, NOCODA must be ranked highly in order to preclude codas. CODACONDITION represents that in Mandarin syllables, codas are restricted to [n], [ŋ] or retroflexed [r]. However, the production of Mandarin output in the pronunciation of English O-O clusters shows that the speaker cannot violate the restrictions on Mandarin phonotactics. Thus, NOCODA and CODACONDITION are undominated.

In addition to conforming to the native phonotactics, the output should be as close to its input as possible. The constraints requiring conformity are the faithfulness constraints, MAX-IO and DEP-IO. MAX-IO and DEP-IO are thus tied in the ranking.

(7) DEP-IO: Every segment in the output must have a correspondent in the input. (No insertion.)

(8) MAX-IO: Every segment in the input must have a correspondent in the output. (No deletion.)

DEP-IO prohibits any insertion of input segments in the output, while MAX-IO forbids any input segment being deleted from the output. That is to say, any difference between the correspondent segments in the input and the output will cause a violation of one of the two constraints.

McCarthy and Prince (2003) state that a number of languages around the world prefer that their surface forms be minimally disyllabic. In addition, following the Prosodic Hierarchy, a prosodic word, a constituent that references morphological information in a generalized manner, must embrace at least one stressed foot. Based on Foot Binary, a foot must be bimoraic or disyllabic, and all syllables are then parsed into feet. Thus, the preferred size of a minimal word in Mandarin is disyllabic because every disyllabic word can be parsed into a binary foot that contains two syllables (Broselow, Chen and Wang 1998; Lu 2006).

This phenomenon has been found in TESs' pronunciation of English monosyllabic words with O-O coda clusters (i.e., [bɛ**st**] and [dɪ**sk**]). Namely, when TESs try to pronounce O-O coda clusters in monosyllabic words, they frequently insert [ə] after the final obstruent instead of deleting one of the obstruents, as in their pronunciation of [bɛ**stə**] and [dɪ**skə**]. MINWD, the preference of two syllables in a word, is then adopted into the ranking.

(9) MINWD: A word must contain at least two syllables.

5.2 Constraint Ranking and Tableaux

As observed in the pronunciation of English O-O coda clusters in monosyllabic words, the TESs do not delete any segment but preserve the final obstruent by inserting [ə]. Thus, the properties of Mandarin syllables, as manifested in their pronunciation, motivate the constraint ranking below:

(10) MINWD>> CODACONDITION, DEP-IO>> NOCODA>> MAX-IO

Mandarin syllable structure prefers the size of a minimal word to be two syllables, so MINWD is then ranked at the top. When pronouncing English O-O coda clusters in monosyllabic words, the TESs insert [ə] after any final obstruent that is not an [n], [ŋ] or retroflexed [r] in order not to violate NOCODA and CODACONDITION. However, from an analysis of their pronunciation of English O-O coda clusters, [ə] epenthesis is evidently found to occur only in monosyllabic words, indicating that the TESs use the deletion strategy more frequently than that of [ə] insertion when pronouncing English O-O clusters in multisyllabic words. Thus, DEP-IO and CODACONDITION need to be ranked above NOCODA and MAX-IO. An example is given below:

Table 6. /dɛsk/→[dɛ.skə] 'desk'

/dɛsk/	MINWD	CODA CONDITION	DEP-IO	NOCODA	MAX-IO
☞a. dɛ.skə			*		
b. dɛ.sək		*	*!	*	
c. dɛs	*!	*		*	*
d. dɛk	*!	*		*	*
e. dɛsk	*!	**		**	
f. dɛ.sə.kə			**!		
g. də.ɛ.sə.kə			**!*		
h. də.ɛə.sə.kə			**!**		

In O-O clusters appearing in the coda position of monosyllabic words, schwa insertion after a word-final obstruent creates another syllable with no coda so that the pronunciation can fulfill MINWD, CODACODITION and NOCODA. In Table 6, candidates (c), (d), and (e) all incur a violation of MINWD for lack of a second syllable, and they are thus the first to be eliminated. Candidates (b), (f), (g), and (h) are ruled out in the second round by incurring violations in DEP-IO. At the cost of violating DEP-IO, candidate (a) can still defeat the other candidates because it conforms to not only MINWD, but also to CODACONDITION.

However, can this constraint ranking (10) manifest the TESs' pronunciation of English O-O coda clusters in monosyllabic words? Let us present another example to illustrate the phenomenon.

Table 7. /pɪtʃt/→[pɪtʃ.tə] 'pitched'

/ pɪtʃt /	MINWD	CODA CONDITION	DEP-IO	NOCODA	MAX-IO
☞ a. pɪtʃ.tə		*	*	*!	
b. pɪ.tʃət		*	*	*!	
c. pɪtʃ	*!	*		*	*
d. pɪt	*!	*		*	*
e. pɪtʃt	*!	**		**	
💣 f. pɪ.tʃə.tə			**		

In Table *7*, candidates (c), (d), and (e) are ruled out first for the violation of MINWD. Candidates (a), (b), and (f) all pass MINWD because they all create a syllable by inserting [ə] after the word-final obstruent. However, constraint ranking (10) cannot pick the attested TESs' pronunciation [pɪtʃ.tə] out. To fulfill MINWD, candidate (b)'s schwa insertion after consonant [tʃ] and candidate (f)'s schwa insertion after consonants [tʃ] and [t] lead the two candidates to incur as many violations as candidate (a) in CODACONDITION and DEP-IO. What's worse, candidate (a) is finally defeated by candidate (f) due to the preservation of the coda [tʃ]. Therefore, to correctly predict the attested TESs' pronunciation [pɪtʃ.tə], it is necessary to discover the common patterns in their pronunciation.

From the TESs' pronunciation of English O-O clusters, the researcher found that the mandatory schwa insertion in monosyllabic words always comes after the word-final obstruent, not after the word-medial obstruent in order not to violate MINWD (i.e., [bɛ**st**] is pronounced as [bɛs**tə̲**] and [kʊ**kt**] as [kʊk**tə̲**]). In addition, it was found that the TESs deleted one of the obstruents instead of inserting a schwa in their pronunciation of English heterosyllabic O-O clusters in multisyllabic words (i.e., [`dɑ**kt**ɚ] is pronounced as [`dɑ**t**ɚ] and [`pɑ**p**ˏ**k**ɔrn] as [`pɑˏ**k**ɔrn]). That is, the TESs allow word-internal deletion, but disallow word-internal epenthesis. Thus, in order to ensure that the schwa insertion comes after the final obstruent, it is necessary to add O-CONTIGUITY-IO into constraint ranking (10). The insertion is mainly for the purpose of fulfilling the Mandarin preference for the size of a minimal word, so MINWD must outrank O-CONTIGUITY-IO.

(11) O-CONTIGUITY-IO = NO INTRUDE: "no internal epenthesis!"
The portion of the output standing in correspondence forms a contiguous string (Kager, 1999).

(12) MINWD>> O-CONTIGUITY-IO, CODACONDITION, DEP-IO>> NOCODA>> MAX-IO

O-CONTIGUITY-IO prefers epenthesis before or after the cluster (Kager 1999). This constraint ensures that the schwa epenthesis comes after the word-final consonant. Thus, the candidates [pɪ.tʃət] and [pɪ.tʃə.tə] will violate O-CONTIGUITY-IO, exemplified as follows:

Table 8. /pɪtʃt/→[pɪtʃ.tə] 'pitched'

/ pɪtʃt /	MIN WD	O-CONTIG -IO	CODA CONDITION	DEP -IO	NO CODA	MAX -IO
☞ a. pɪtʃ.tə			*	*	*	
b. pɪ.tʃət		*	*	*!	*	
c. pɪtʃ	*!		*		*	*
d. pɪt	*!		*		*	*
e. pɪtʃt	*!		**		**	
f. pɪ.tʃə.tə		*		**!		
g. pə.ɪ.tʃ.tə		*		**!		
h. pə.ɪ.tʃə.tə		**		*!**		

Let us turn to the TESs' pronunciation of [dɛ.skə]. When assessed by constraint ranking (12), is candidate [dɛ.skə] the most optimal one? The following is the case:

Table 9. /dɛsk/→[dɛ.skə] 'desk'

/dɛsk/	MIN WD	O-CONTIG -IO	CODA CONDITION	DEP -IO	NO CODA	MAX -IO
☞ a. dɛ.skə				*		
b. dɛ.sək		*	*!	*	*	
c. dɛs	*!		*		*	*
d. dɛk	*!		*		*	*
e. dɛsk	*!		**		**	
f. dɛ.sə.kə		*		*!*		
g. də.ɛ.sə.kə		**!		***		
h. də.ɛə.sə.kə		**!*		****		

Even if O-CONTIGUITY-IO is added into constraint ranking (10), candidate (a) does not violate it because it does not insert any segment between the fricative [s] and the stop [k]. Instead, candidates (b), (f), (g), and (h) all incur a violation of O-CONTIGUITY-IO by inserting [ə] between the O-O cluster. Therefore, in constraint ranking (12), candidate (a) is selected as optimal.

Next, let us turn to the data in (3), Deletion of the Preceding Obstruent of O-O Clusters in Multisyllabic Words. Codas of a multisyllabic word are deleted. That means that when English O-O clusters are in the heterosyllabic position in multisyllabic words, the TESs pronounce them by deleting the preceding obstruent instead of inserting [ə] after the succeeding obstruent. In such a case, either [ə] epenthesis after an illicit coda or a coda deletion could be used as the repair strategy to pass CODACONDITION. Therefore, both MAX-IO and DEP-IO must be included in the ranking. From the data in (3), the TESs tend to use the repair strategy of obstruent deletion, not schwa insertion. According to their pronunciation, MAX-IO must be ranked in the lowest position.

Universally, syllables prefer the structure of V or CV rather than that of VC, so heterosyllabic O-O clusters are syllabified as "CV**C.** **C**V" or "CV. **CC**V". When heterosyllabic O-O clusters are syllabified as "CV**C.** **C**V", (i.e., the preceding C is combined with the front V as a coda, and the succeeding C is combined with the following V as an onset), the TESs pronounce them by frequently deleting the preceding obstruent instead of the succeeding one. However, when they are syllabified as "CV. **CC**V", (i.e., O-O onset clusters), most of the TESs pronounce them correctly. The TESs will not delete or insert any segment in the onset position. This shows that MAX-IO(ONSET) and DEP-IO(ONSET) are ranked in the top position.

(13) MAX-IO(ONSET): Every onset segment in the input must have a correspondent in the output. (No deletion of onset segments.)

(14) DEP-IO(ONSET): Every onset segment in the output must have a correspondent in the input. (No insertion of onset segments.)

(15) MAX-IO(ONSET), DEP-IO(ONSET)>> CODACONDITION, DEP-IO>> MAX-IO

MAX-IO(ONSET) and DEP-IO(ONSET) ask for the identity of any correspondent onset segments in the input and the output. Ranking MAX-

IO(ONSET) and DEP-IO(ONSET) at the top makes sure that any deletion or insertion of onset segments will lead to them being the first to be ruled out, as exemplified in the following cases:

Table 10. /`pɪktʃɚ/→[pɪ.tʃɚ] ‘picture’

/pɪk.tʃɚ/	MAX-IO (ONSET)	DEP-IO (ONSET)	CODA CONDITION	DEP -IO	MAX -IO
a. pɪk.tʃɚ			*!		
☞ b. pɪ.tʃɚ					*
c. pɪ.kə.tʃɚ				*!	
d. pɪ.kɚ	*!				*
e. pɪk.tʃə.ɚ			*!	*	
f. pɪ.kə.tʃə.ɚ				*!*	
g. pə.ɪ.kə.tʃə.ɚ				*!**	
h. pə.ɪ.kə.tʃɚ				**	

Table 11. / ɑk`toubɚ /→ [ɑ.tou.bɚ] ‘October’

/ ɑk.tou.bɚ /	MAX-IO (ONSET)	DEP-IO (ONSET)	CODA CONDITION	DEP -IO	MAX -IO
a. ɑk.tou.bɚ			*!		
b. ɑ.kə.tou.bɚ				*!	
☞ c. ɑ.tou.bɚ					*
d. ɑ.kou.bɚ	*!				*
e. ɑk.tə.ou.bɚ			*!	*	

Table 12. /`dɑktɚ/→[dɑ.tɚ] ‘doctor’

/dɑk.tɚ/	MAX-IO (ONSET)	DEP-IO (ONSET)	CODA CONDITION	DEP -IO	MAX -IO
☞ a. dɑ.tɚ					*
b. dɑk.tɚ			*!		
c. dɑ.kə.tɚ				*!	*
d. dɑ.kɚ	*!				*
e. dɑk.tə.ɚ			*!	*	

In Table 12, candidate (d) is eliminated first because it incurs a fatal violation of MAX-IO(ONSET) due to deleting the onset segment [t] in the input. In order not to be eliminated by CODACONDITION, candidate (c) inserts [ə] after the preceding obstruent [k]. However, the insertion violates DEP-IO, which ranks higher than MAX-IO, and thus candidate (c) is defeated by candidate (a), which violates only the lowest constraint, MAX-IO. Candidate (e) violates DEP-IO by inserting [ə] after the onset [t]. Candidate (b) is the third to be ruled out for violating CODACONDITION due to its preservation of coda [k]. Candidate (a) is the optimal pronunciation because it violates only the lowest MAX-IO by its obstruent [k] deletion.

When the voiceless fricative [s] is combined with an oral stop in the onset position, the TESs neither insert nor delete any segment. DEP-IO(ONSET), MAX-IO(ONSET), and O-CONTIGUITY-IO are thus ranked in the highest positions due to the TESs' pronunciation of onset O-O clusters.

(16) MAX-IO(ONSET), DEP-IO(ONSET)>> O-CONTIGUITY-IO, DEP-IO>> CODACONDITION

Table 13. /dɪˋskʌs/→[dɪ.skʌs] 'discuss'

/dɪ.skʌs/	MAX-IO (ONSET)	DEP-IO (ONSET)	O-CONTIG-IO	DEP -IO	CODA CONDITION
☞ a. dɪ.skʌs					*
b. dɪ.kʌs	*!				*
c. dɪ.sʌs	*!				*
d. dɪ.sə.kʌs		*!	*	*	*
e. dɪ.skə.ʌs			*!	*	*
f. dɪ.skʌ.sə				*!	

In Table 13, candidates (b) and (c) lack in their identity between the correspondent input and output onset segments. They are thus ruled out for a violation of MAX-IO(ONSET). As for candidates (d) and (e), they both insert [ə] in the word-medial position, violating O-CONTIGUITY-IO and DEP-IO. In addition to the violations of O-CONTIGUITY-IO and DEP-IO, candidate (d) also violates the top-ranked DEP-IO(ONSET) constraint due to its insertion of [ə] in the onset position. Candidate (f) violates DEP-IO in order not to have a coda, while candidate (a) violates CODACONDITION because of its preservation of coda [s]. Candidate (a) finally defeats candidate (f) at the expense of its violation of CODACONDITION.

The TESs usually insert [ə] after the final obstruent when pronouncing English O-O coda clusters in monosyllabic words. However, this is not the case when pronouncing the word '*discuss*'. They pronounce it as [dɪ.skʌ**s**], not [dɪ.skʌ**sə**]. Namely, they do not insert [ə] after fricatives, affricates, or nasals. In order not to avoid the wrong choice of candidate [sprɪ**ŋə**], we need to test if constraint ranking (16) can still manifest.

(17) MAX-IO(ONSET), DEP-IO(ONSET)>> CODACONDITION, DEP-IO, O-CONTIGUITY-IO >> MAX-IO

Table 14. /sprɪŋ /→ [sprɪŋ] 'spring'

/sprɪŋ /	MAX-IO (ONSET)	DEP-IO (ONSET)	CODA CONDI	O-CONTIG-IO	DEP -IO	MAX -IO
☞ a. sprɪŋ						
b. prɪŋ	*!					*
c. srɪŋ	*!					*
d. spə.rɪŋ				*!	*	
e. sə.pə.rɪŋ				*!*	**	
f. sprɪ.ŋə					*!	

In the case of constraint ranking (17), it is the TESs' pronunciation [sprɪŋ] instead of [sprɪŋə] that can be successfully picked out. Let's go back to their pronunciation of the word '*discuss*' to see how constraint ranking (17) manifests.

Table 15. /dɪskʌs/→[dɪ.skʌs] 'discuss'

/dɪ.skʌs/	MAX-IO (ONSET)	DEP-IO (ONSET)	CODA CONDI	O-CONTIG-IO	DEP -IO	MAX -IO
☞ a. dɪ.skʌs			*			
b. dɪ.kʌs	*!		*			*
c. dɪ.sʌs	*!		*			*
d. dɪ.sə.kʌs		*!	*	*	*	
e. dɪ.skə.ʌs			*	*!	*	
💣 f. dɪ.skʌ.sə					*	

As shown in Table 15, candidate (a) incurs a violation of CODACONDITION for preserving the [s] coda, and candidate (f) violates DEP-IO due to the schwa insertion. Therefore, candidate (a) cannot defeat candidate (f) since they both have one violation at the same level in constraint ranking (17). In order to select candidate [dɪ.skʌs], one more constraint, ANCHOR-IO-R, needs to be added into constraint ranking (17). ANCHOR-IO-R discourages any insertion or deletion after the right edge of the word, but the insertion or deletion is irrelevant to medial codas. ANCHOR-IO-R must be ranked below CODACONDITION because [n], [ŋ], and retroflexed [r] can be the codas in Mandarin syllables. If ANCHOR-IO-R outranks CODACONDITION, any word-final illicit coda consonants would be wrongly selected.

(18) ANCHOR-IO-R: The right edge of the input must correspond to the right edge of the output.

(19) MAX-IO(ONSET), DEP-IO(ONSET)>> O-CONTIGUITY-IO, DEP-IO, CODACONDITION>> ANCHOR-IO-R>> MAX-IO

Table 16. /dɪskʌs/→[dɪ.skʌs] 'discuss'

/dɪ.skʌs/	MAX-IO (ONSET)	DEP-IO (ONSET)	CODA CONDI	O-CONTIG-IO	DEP -IO	ANCHOR -IO-R	MAX -IO
☞ a. dɪ.skʌs			*				
b. dɪ.kʌs	*!		*				*
c. dɪ.sʌs	*!		*				*
d. dɪ.sə.kʌs		*!	*	*	*		
e. dɪ.skə.ʌs			*	*!	*		
f. dɪ.skʌ.sə					*	*!	

With constraint ranking (19), candidate (f) is defeated by candidate (a) since it has incurred one more violation, that of ANCHOR-IO-R by inserting a schwa [ə] after the right-edge consonant. Consider one more instance below:

Table 17. /ɪnspaɪr /→ [ɪn.spaɪr] 'inspire'

/ ɪn.spaɪr /	MAX-IO (ONSET)	DEP-IO (ONSET)	CODA CONDI	O-CONTIG-IO	DEP -IO	ANCHOR -IO-R	MAX -IO
☞a. ɪn.spaɪr			*				
b. ɪn.spaɪrə					*	*!	
c. ɪn.sə.paɪr		*!	*	*	*		
d. ɪn.spə.aɪr			*	*!	*		
e. ɪn.paɪr	*!		*				*
f. ɪn.saɪr	*!		*				*

The final constraint ranking of the TESs' pronunciation of English O-O clusters is thus proposed as:

(20) MAX-IO(ONSET), DEP-IO(ONSET), MINWD>> O-CONTIGUITY-IO, CODACONDITION, DEP-IO>> ANCHOR-IO-R>> NOCODA>> MAX-IO

The following tableaux demonstrate how the constraints work to account for the TESs' pronunciation of English O-O clusters.

Table 18. / wɑʃt /→[wɑʃ.tə] 'washed'

/wɑʃt /	MAX-IO(ONSET)	DEP-IO(ONSET)	MINWD	O-CONTIG-IO	CODA CONDI	DEP-IO	ANCHOR-IO-R	NOCODA	MAX-IO
a. wɑʃt			*!		**			**	
☞ b. wɑʃ.tə					*	*	*	*	
c. wɑ.ʃət				*	*	*!		*	
d. wɑʃ			*!		*		*	*	*
e. wɑt			*!		*			*	*
f. wɑ.ʃə.tə				*!		**	*		

Table 19. /pɑpkɔrn /→[pɑ.kɔrn] 'popcorn'

/ pɑp.kɔrn /	MAX-IO(ONSET)	DEP-IO(ONSET)	MINWD	O-CONTIG-IO	CODA CONDI	DEP-IO	ANCHOR-IO-R	NOCODA	MAX-IO
a. pɑp.kɔrn					**!			***	
☞ b. pɑ.kɔrn					*			**	*
c. pɑ.pə.kɔrn				*	*!	*		**	
d. pɑ.pɔrn	*!				*			**	*
e. pɑp.kɔr.nə					**!	*	*	**	
f. pɑ.kɔr.nə					*	*!	*	*	*
g. pɑ.kɔ.rən				*		*!		*	*

Table 20. / mɪsteɪk /→[mɪ.steɪk] 'mistake'

/ mɪ.steɪk /	MAX-IO(ONSET)	DEP-IO(ONSET)	MINWD	O-CONTIG-IO	CODA CONDI	DEP-IO	ANCHOR-IO-R	NOCODA	MAX-IO
☞a. mɪ.steɪk					*			*	
b. mɪ.steɪ.kə						*	*!		
c. mɪ.teɪk	*!				*			*	*
d. mɪ.seɪk	*!				*			*	*
e. mɪ.sə.teɪ.kə		*!		*		**	*		
f. mɪ.sə.teɪk		*!		*	*	*		*	
g. mə.steɪ				*		*!	*		**

5.3 Implications for the Constraint Ranking

Constraint ranking (20) indicates that the TESs' L1, Mandarin, indeed interferes in their pronunciation of English O-O clusters, and that it is the differences in the syllable structures between Mandarin and English that cause the interference. Initially, the constraint ranking will be very similar to that in the language learners' L1, while, with the development of the language learners' proficiency in the L2, their interlanguage grammar will become more similar to that of the constraint ranking in their L2. Once teachers have a theoretically sound understanding of L1 interference, they will realize the problems language learners are facing when learning the L2. They will then understand what causes their learners to produce incorrect outputs.

6. IMPLICATIONS FOR TEACHING

Chang (2004) studied the errors that Chinese EFL learners made when processing English consonant clusters. The study, based on the Contrastive Analysis Hypothesis (CAH), noted that the complexity of the Chinese syllable structure is different from that of the English syllable structure (i.e., English allows complex consonant clusters while Chinese only allows onset CG clusters). Due to the differences in syllable structure between the L1 and the L2, interference from the L1 resulted in the Chinese learners encountering difficulties in pronouncing English consonant clusters. The following will give some pedagogical suggestions based on the CAH, which emphasizes that errors resulting from the transfer of the language learners' L1 must be corrected and that the correct pronunciation may need to be taught quite explicitly.

6.1 Contrastive Analysis Hypothesis

Contrastive analysis hypothesis, which was popular in the 1950s and 1960s, assumes that language learners' errors can be predicted based on a comparison of the similarities and differences between the language learners' L1 and the target language (L2) (Brown 2007; Crystal, 2003; Fries, 1952). Lado (1957, cited in Brown, 2007) made the claim that by comparing language learners' L1 with the target language (i.e., L2) to be learned, it is possible to make predictions and then give an account of the patterns which will or will not induce difficulty in learning. In other words, by comparing the elements of the L1 with those of L2, elements similar to those of the native language will be found to be easier to learn than elements that are different from those of the L1. Therefore, form-focused instruction and corrective feedback are expected to be very important for the reason that they will draw the learners' attention to the target features of the input, and, then, the learners, through utilizing these forms of interaction, will then be better enabled to focus on the target features.

6.2 Pedagogical Suggestions Focused on Form-Based Instruction and Corrective Feedback

With the utilization of Optimality Theory to analyze the strategies that TESs use to simplify the pronunciation of English O-O clusters, L1 (Mandarin) interference is then identified as the main potential cause of the simplification. Language teachers can thus now identify specific pronunciation features that pose problems for TESs: directly asking their TESs to focus on those O-O clusters in the heterosyllabic or coda position.

Form-focused instruction and corrective feedback aim to make learners aware of the features in the learning targets that may cause learners to make errors because the features are different from those in the language learners' L1 (Doughty and Williams, 1998; Ellis, 2001; Spada, 1997). That is, the instruction must provide a great deal of input with the correct pronunciation of English O-O clusters, some explicit teaching of how to pronounce English O-O clusters in the heterosyllabic or coda position, and corrective feedback when the language learners mispronounce, as mentioned in Derwing and Munro's (2005) study. Their study indicated that one of the effective ways to provide input is to offer language learners enough listening exposure to correct spoken models. With attentive, regular listening to correct spoken models, learners can probably improve their pronunciation.

However, language learners' awareness of their pronunciation problems is just the first step. Once language learners are made aware of such problems, language teachers can then devote special sessions providing learners with drills to aid them in avoiding interference errors. This helps language learners to recognize pronunciation problems whenever they occur and to correct their own pronunciation of English O-O clusters (Breitkreutz, Derwing and Rossiter, 2002). In addition, language teachers can intervene in learners' spoken production in a timely manner to awaken them to the correct pronunciation of English O-O clusters.

Another way to help TESs to overcome interference problems is to engage the assistance of the students who are already producing the sounds correctly. By learning from the successful experience of their peers, those with poor pronunciation can figure out where they went wrong and how they can correct their pronunciation errors in an effective way.

Additionally, it may also be helpful to refer to aspects of the pronunciation of the Southern Min dialect when correcting Taiwanese language learners' pronunciation of English O-O clusters since many people in Taiwan can speak Southern Min. Despite the fact that Southern Min, like Mandarin, does not tolerate O-O clusters in coda positions, it does contain entering tone words. Southern Min entering tone words have final unreleased stops similar to the English final unreleased voiceless stops, such as the [k] sound in [kɪ**k**], the [t] sound in [kɪ**t**], and the [p] sound in [li:**p**] (Chung, 1996; Lu, 2006). Therefore, language teachers can draw learners' attention to the Southern Min entering tone words and connect their experience of pronouncing such Southern Min words with the pronunciation of English O-O clusters.

As mentioned above, TESs could improve their pronunciation of English O-O clusters in an effective way based on an understanding derived from the analysis of the present study, and with the use of form-based instruction and corrective feedback.

7. CONCLUSION

In this paper, the researcher analyzes how Mandarin interferes in TESs' pronunciation of English O-O clusters by use of Optimality Theory (Prince and Smolensky 1993). The tendencies of TESs in their pronunciation of English O-O clusters as observed in the data are thus studied via constraint interaction, and the resultant constraint ranking is as listed below:

(21) Constraint ranking of pronunciation of English O-O clusters by TESs

MAX-IO(ONSET), DEP-IO(ONSET), MINWD
>>CODACONDITION, O-CONTIGUITY-IO, DEP-IO
>>ANCHOR-IO-R>> NOCODA>> MAX-IO

The analysis above has shown that Mandarin interference does play a significant role in the pronunciation of English O-O clusters by TESs**.** It would be interesting to test the constraint hierarchy proposed above with further data of TESs' pronunciation of English O-O clusters. However, Mandarin interference in TESs' pronunciation of English consonant clusters is more complicated than what has been shown here, as evidenced in their pronunciation of English obstruent-liquid clusters. However, while it would be much better if we had been able to analyze all the possible TESs' pronunciation of English consonant clusters, TESs' pronunciation of English obstruent-liquid clusters was not investigated in this paper. The researcher leaves this issue for further research.

In addition, the experiment was conducted in in an elementary school where approximately one-sixth of the student body has parents from foreign countries. Therefore, whether the pronunciation of TESs shows a similar or different pattern compared to the elementary school children with parents from foreign countries is another interesting issue needing to be investigated to confirm whether Mandarin interference does indeed have an influence on TESs' pronunciation of English consonant clusters. Future research may add participants from other countries to illuminate the answer to this question.

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APPENDIX A

Read-Aloud Practice

小朋友請依序並大聲地念出下列的 24 個英文單字

1. best
2. dogs
3. mask
4. October
5. insect
6. spring
7. rectangle
8. octopus
9. left
10. cats
11. mix
12. past
13. street
14. display
15. desk
16. socks
17. six
18. spell
19. speak
20. eggs
21. doctor
22. notebook
23. stop
24. picture

APPENDIX B

Parents' Consent Template

親愛的家長您好:

我是____________的英文老師，也是國立台灣師範大學英語研究所語言學組博士班的學生。為探究國小學童的母語(國語)音節結構是否會對其發英語阻音-阻音子音串有所干涉，且若真有干涉時，學童所採取的應變策略是否根據其母語音節結構，本研究將執行一項實驗，要邀請您的孩子參與。本研究將選擇 20 個四年級學童進行認讀英語單字實驗，期能從中找出母語(國語)和其所學外國語言(英語)之間是否存在語言干涉的關係。

由於本研究者在多年的英語教學中，觀察到國小學童在發英語阻音-阻音子音串的單字時會有困難，使得學童們念讀英語某些單字時會因發音怪而產生挫折，進而影響他們開口念讀、說英語的意願。本研究者經閱讀先前相關研究發現，如此發音困難的現象可能是受學童本身的母語音節結構影響，故進而設計此實驗，以探究此關係是否存在。

本研究計畫將於二周後實施。主要活動有二，首先由本研究者帶領學童念讀二本針對國小中年級學童設計的英語故事書，本活動將進行二堂課，利用周一和周三早自修進行。接著進行個別學童念讀英語單字測驗，每位參與者須於 10 分鐘內念完 24 個英語單字，念讀過程將全程錄音。本活動將進行一周，於當周一、三、四早自修和周一、二、四午休時進行。

研究結果僅供學術論文發表用，絕不挪作它用，亦不影響學童在校成績。希望您同意貴子弟參與這項計畫，如您同意請於家長同意書上簽名，謝謝您的參與。

祝　　身體健康　事事如意　　　　　　　　　　ooo 敬上 106.12.06

☐ 同意参加此實驗方案

☐ 不同意参加此實驗方案，因為____________________________

運用優選理論
分析國語對英語阻音-阻音串發音的干涉

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已有很多學者從事第一語言對第二語言習得干涉的研究，而本研究主要的目的是利用優選理論(Optimality Theory)來分析台灣以國語為母語的國小學童發英語阻音-阻音串時，國語對其發音的干涉，並進一步根據研究發現和對比分析假說，提供有效的教學建議。
英語的音節結構可允許子音串，但國語的音節結構並不允許阻音-阻音串出現在音節的邊緣。台灣國小學童受國語的干涉，會利用二種策略來簡化英語阻音-阻音串的發音：插入中央元音/ə/或刪除其中一個阻音。研究發現此制約排序層級(constraint ranking) MAX-IO(ONSET), DEP-IO(ONSET), MINWD>> O-CONTIGUITY-IO, CODACONDITION, DEP-IO>> ANCHOR-IO-R>> NOCODA>> MAX-IO 著實反應國語會對其以國語為母語的台灣國小學童發英語阻音-阻音串時進行干涉。

關鍵字：優選理論、英語子音串、語言干涉、第二語習得、對比分析假說