Concentric: Studies in English Literature and Linguistics
28.2 (June 2002): 1-25

Asymmetry in Mandarin Consonant Articulations: Evidence from Slips of the Tongue

I-Ping Wan
National Chengchi University

This paper aims to assess the cognitive validity of the underspecification of ([+anterior]) coronals and focus on whether there is any asymmetrical behavior among dentals, retroflexes, and velars with respect to the palatalization process in Mandarin. A corpus of 3500 slips of the tongue data was analyzed and evidence presented. The analysis shows that actual speakers of Mandarin use underspecified representations on line during language production, and that coronals take part in phonological patterns which are different from those of other places of articulation.

Key words: slips of the tongue, language production, underspecification

1. Introduction

Studies of slips of the tongue that have been conducted over the past several decades have used the patterns and constraints observed in extensive collections of errors to argue for the validity of phonological units as processing units, and for particular phonological theories or cognitive processing models (Fromkin 1973, Stemberger 1983, Dell 1984, Shattuck-Hufnagel 1986, Levelt 1989, Bock & Levelt 1994). There has been much work which has attempted to determine the psychological validity of various linguistic claims ranging from the existence of certain units to the existence of particular rules. Such studies have provided evidence for the cognitive reality of such phonological phenomena as features, phonemes (both segment-sized units and allophones), productive phonological and morphological processes, and syllables. However, the majority of research into slips of the tongue has been done on English and related languages. Although a few studies involving slips of the tongue in Mandarin have been done recently, questions regarding current phonological theories have not been assessed with such a method (see Chen 1999, Wan 1997, 1999, 2000, 2001, 2002, Wan & Jaeger 1998).

During the past several decades there have been a number of majority advances in

phonological theory. In *The Sound Pattern of English* (Chomsky and Halle 1968), it was assumed that features were grouped into unordered matrices. In *Autosegmental Phonology* (Goldsmith 1976), it was shown that on a language-specific basis, some features must be represented on a separate tier different from segments. Clements (1985) further proposed *Feature Geometry*, in which a universal structure assigned a constituent structure to a segment, with features grouping on class nodes in a hierarchical organization. Most current researchers assume that some feature specifications are absent from the underlying representations and are filled in either during derivations or at a later stage (e.g. Archangeli 1988, Mester & Ito 1989, Stemberger 1991, 1992). Questions of underspecifications are then raised as to what feature specification is absent from the underlying representation, and as to when it is filled in.

It has been long known that coronals are the most frequent consonants in languages, with the exception of Hawaiian (Maddieson, 1987:31). Keating (1991) has proposed that coronals have special status because they include more contrasts of both place and manner than do other consonant classes. Avery and Rice (1989) have suggested that in some languages coronals behave asymmetrically with respect to other consonants since coronals assimilate to other places of articulation while velars and labials do not. They postulate that universal grammar provides a markedness theory which supplies information concerning which features are underspecified. Furthermore, Stemberger & Stoel-Gammon (1991) and Stemberger (1991, 1992) have found that actual speakers of English use underspecified representations on-line during language production and perception. Such studies have provided both internal and external evidence to show that coronals take part in phonological patterns that are different from those of other places of articulation.

The first purpose of this paper is to present evidence regarding the psychological reality of the underspecification of ([+anterior]) coronals in Mandarin. The second purpose is to see whether there is an asymmetry among dentals, retroflexes and velars with respect to the palatalization process. I will look at these issues with reference to a corpus of 3500 slips of the tongue collected from speakers of a dialect of Mandarin spoken natively in Taiwan.

This paper is organized as follows. In the following section I will present a

detailed account of the methodology for the collection and analysis of the slips of the tongue data. In the third section I will first lay out the facts regarding the consonant phones in Taiwan Mandarin, including the restrictions on their contextual occurrences, followed by a discussion of the competing theories regarding the basic palatal category of Mandarin. Section four presents the results, and the analysis of those results in terms of some competing hypotheses. In addition, section four summarizes the study, discussing in detail the phonological analysis supported by this study, and relating it to a psycholinguistic model of speech production planning.

2. Methodology

Slips of the tongue have been shown to be invaluable evidence for the cognitive status of specific linguistic units and processes in specific languages, and this is the rationale for using the slips methodology for looking at the phonological system of Mandarin.

The current study is based on 3500 slips of the tongue selected from the corpus collected by the author, from which a subset of 643 errors was selected for relevance to issues of interest in this paper. These errors were collected between 1995 and 1998 in naturalistic settings from native speakers of Taiwan Mandarin. There were approximately twenty subjects who contributed data. Most errors were gathered from tape-recorded free conversations, during which the subjects did not know they were being recorded. After each conversation, the subjects were informed that the conversation had been recorded, and permission was obtained to use their data. However, when slips occurred in situations where speakers were not being recorded, the errors were immediately written in a notebook; for each error I recorded the complete utterance including self-corrections, and relevant contextual information; portions were written in phonetic transcription. Subjects ranged from monolingual to trilingual; all but one spoke Mandarin as their first language, with English and Taiwanese as their other language(s). However, all the errors were collected when the speakers were conversing in Mandarin; only twelve errors in the corpus, which are not discussed in this paper, show a bilingual influence. Therefore we take the majority of these errors to accurately reflect the processing involved in speaking Mandarin.

3. Overview

The following consonant inventory involving the dentals, retroflexes, alveopalatals and velars is presented as in Table (1) with the place feature specification in phonetic representations[1].

Table (1)

	Dentals			Retroflexes			Palatals			Velars		
	s	ts	ts^h	ʂ	tʂ	$tʂ^h$	ɕ	tɕ	$tɕ^h$	x	k	k^h
Labial	-	-	-	-	-	-	-	-	-	-	-	-
Dorsal	-	-	-	-	-	-	-	-	-	+	+	+
Coronal	+	+	+	+	+	+	+	+	+	-	-	-
Anterior	+	+	+	-	-	-	-	-	-	-	-	-

As shown in Table (1), Mandarin distinguishes several coronal subarticulations such as dental [ts, ts^h, s], retroflex [tʂ, $tʂ^h$, ʂ] and alveopalatal [tɕ, $tɕ^h$, ɕ]. According to Hall (1997), Paradis and Prunet (1991), and Spencer (1997), only one of the subarticualtions can be exhaustively characterized as having the predictable value for each of the coronal features, and only one of the subarticulations can be totally underspecified, and that is [+anterior], which refers to dentals in Mandarin.

One of the fundamental goals of every phonological theory is to account for the nature of the basic units of speech sounds, and the relationships between these units and their contextual variants. This relationship is equally crucial to phonological theory whether it is called 'phonemes and allophones', 'underlying and surface forms', or 'input and output'. Purely structural analyses of phonological systems can often produce several hypotheses regarding the phonemic inventory and its surface reflexes in any particular language, all of which are supportable by the contrast and alternation patterns of the language. In discussing the consonant phonemes in Mandarin phonology, the problem of the non-uniqueness of phonemic solutions of phonetic systems is often raised (Chao 1934). It has been a controversial issue for decades

[1] The subjects under this study are all native speakers of Mandarin spoken in Taiwan. The main difference among subjects is that most of the speakers' dialects reflect a general sound change currently taking place in Southern China and Taiwan, whereby the retroflex affricates are being lost and are replaced by dental affricates. However, some other speakers in my subject group continue to distinguish dental from retroflex affricates. Therefore, in the chart the retroflex affricates are remained in the consonant inventory.

whether the palatal consonant set [ɕ, tɕ, tɕʰ] is derived from the dental set [s, ts, tsʰ], the retroflex set [ʂ, tʂ, tʂʰ], or the velar set [x, k, kʰ], since the palatal set is only followed by the high front vowel [i, y] and glides [j, ɥ], whereas the dentals, retroflexes, and velars do not occur in palatal environments. Thus, the palatals are in complementary distribution with the three other series, and a longstanding debate has been: to which phonemes do the palatalized allophones belong?

The conflicting analyses include the following: Diachronically, some palatals are regarded as being derived from the dental sibilants, and others from the velar series (Lin 1989). Synchronically, palatals are sometimes considered to have resulted from the palatalization of velars (Chao 1934, 1968, Pulleyblank 1983, Hsueh 1985, Lin 1989); however, other analyses have treated them as being derived from the dental series (Hartman 1944, Hockett 1947, 1950, Chen 1996). Still others have regarded palatals to be neither allophones of velars nor dental sibilants, but have considered them to be underlyingly palatal segments, i.e. phonemes (Tung 1954, Cheng 1973, Duanmu 1990, Wu 1994, Tse 2000).

In the following, I will present details of the underspecification of coronals and of the above various analyses of the palatals.

4. Findings

4.1 Coronals in Consonant Substitution Errors

We begin our analysis by examining the behavior of coronals in the slips of the tongue data. In Mandarin, the error phenomena involve the interaction of coronals with other places of articulation. In looking at each set of place of articulation, the following question will be asked, based on data from syntagmatic phonological errors:

1. In the initial single consonant substitution errors in which a single target unit of a consonant is deleted and replaced by the source unit at the same place of articulation, which target and source unit that has the same place of articulation will be involved with high rates of substitution errors?
2. When one consonant phone is substituted for another, which place of articulation will be replaced more frequently than the others?

It should be noted here that in all of the examples, the following format is

followed. In the row headed by 'I', the intended Mandarin utterance is given in IPA with the English glosses below; tones are given in tone numbers after the segments as follows: Tone 1 = 55, Tone 2 = 35, Tone 3 = 21, Tone 4 = 51. Then in the row headed by 'E', the error utterance is given. Under the error utterance is a translation of the intended utterance, followed either by a translation of the error utterance (after the arrow), or the word 'meaningless', indicating that the error production resulted in a meaningless (either ungrammatical or uninterpretable) utterance. In the intended and error utterances, the 'source' unit(s) of the error (that is, the units which caused the error) are in boldface; the 'target' unit(s) (that is, the units planned for the intended utterance which were produced erroneously in the error) are underlined; and the actual 'error' (the elements spoken erroneously) are both boldfaced and underlined.

In the corpus used for the present study, there are 375 involving the errors in which both target and source units share the same place of articulation. Ninety-five cases show that both target and source units involve bilabials; one hundred forty-five errors show that both target and source units involve dentals; ninety errors show that both target and source units are palatals; only forty-five errors show that both target and source units include velars. Examples for each type of error which is relevant under this study are provided below.

(1) **Bilabial → Bilabial**

I: **p**a21-**p**a35 ma51 m̲a55 →

Dad blame Mom

E: **p**a21-**p**a35 ma51 **p̲**a55

'Dad blamed Mom' → (meaningless)

In (1), the bilabial oral stop [p] is perseverated and substituted for the nasal bilabial [m]. This shows a case where a bilabial consonant phone is substituted for another one.

(2) **Dental → Dental**

I: tow55 pu51 n̲a35 →

all no pick up

E: tow55 pu51 t̲a35

'not to pick (them) up' → (meaningless)

In (2), the dental oral stop [t] is perseverated and substituted for the nasal dental [n]. This shows a case where a dental consonant phone is substituted for another one.

(3) **Palatal → Palatal**

I: wɔ21 pu35 sɨ51 na51-mɤ ɕi21-xwan55 tɕjɑw55-su55 →

I not am that like teach

E: wɔ21 pu35 sɨ51 na51-mɤ ɕi21-xwan55 ɕjɑw55-su55

'I am not in fond of teaching.' → (meaningless)

In example (3), the palatal fricative [ɕ] is perseverated and substituted for the palatal affricate [tɕ], showing a case where a palatal consonant phone is substituted for another.

(4) **Velar → Velar**

I: noŋ51-tɑw51 ly51-kʰa21-tɤ-xwa51 →

use-COMP green card-if

E: noŋ51-tɑw51 ly51-xa21-tɤ-xwa51

'if (he) gets the Green Card' → (meaningless)

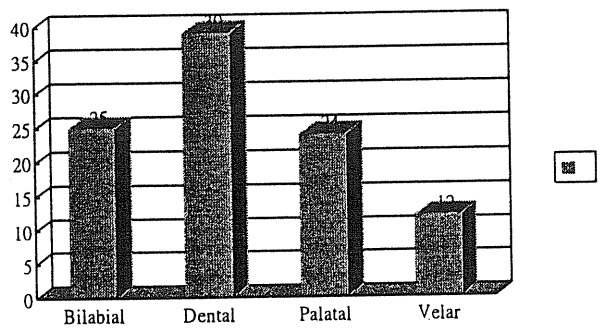
In example (4), the velar fricative [x] is anticipated and substituted for the velar stop [kʰ], showing a case where a velar consonant phone is substituted for another.

Table (2) summarizes the number of consonant substitution errors in which both target and source units share the same place of articulation. Consonant substitution errors involving coronal place of articulation far outnumber other places of articulation. Table (3) shows that there is a statistically significant difference in the number of times dentals are interacted as compared to other places of articulation (including marked coronals) and that dentals tend to be involved with high rates of substitution errors.

Table (2)

	N	Total N=375
Bilabial → Bilabial	95	25%
Dental → Dental	145	39%
Palatal → Palatal	90	24%
Velar → Velar	45	12%

Table (3)



The sample examples for each type of error category are provided below, and the number of substitution errors is listed in Table (4).

(5a) **Dental → Bilabial**

I: maw55 tsaw35 **p^h**aw21-tjaw51-lɤ →

cat early run-away

E: maw55 tsaw35 **p^h**aw21-**p^h**jaw51-lɤ

'The cat already ran away' → (meaningless)

In example (5a), the bilabial stop [p^h] is perseverated and substituted for the dental stop [t], showing a case where a dental stop is replaced by a labial consonant phone.

(5b) **Bilabial → Dental**

I: ʂej35 ɕjɑw21-tɤ ʂɤ35-mɤ ʂi35-xow51 xwej51 xɑw21 →

who know what time will good

E: ʂej35 ɕjɑw21-tɤ ʂɤ35-tɤ ʂi35-xow51 xwej51 xɑw21

'Who knows when (the situation) will get better?' → (meaningless)

In example (5b), the dental stop [t] is perseverated and substituted for the bilabial nasal [m], showing a case where a dental stop is substituted for a bilabial nasal consonant phone.

(6a) **Dental → Palatal**

I: xən21 pu51 ɕjɑŋ21 njɛn51- ʂu55 →.

very not want study

E: xən21 pu51 ɕjɑŋ21 ɕjɛn51- ʂu55

'(I) don't want to study' → (meaningless)

In example (6a), the palatal fricative [ɕ] is perseverated and substituted for the dental nasal [n], showing a case where a dental nasal is replaced by a palatal consonant phone.

(6b) **Palatal → Dental**

I: wɔ21 tsʰaj35 pu51 tɕjɑw55 tʰa55 →

I still not teach him

E: wɔ21 tsʰaj35 pu51 tʰjɑw55 tʰa55

'I don't want to teach him' → (meaningless)

In example (6b), the dental stop [tʰ] is anticipated and substituted for the palatal affricate [tɕ], showing a case where a dental stop is substituted for a palatal consonant phone.

(7a) **Dental → Velar**

I: ts^{h}ɤ55-tsɨ tsoŋ21-jɑw51 **k^{h}**aj55 ts^{h}u55-laj35[2] →

car anyway drive out

E: **k^{h}**ɤ55-tsɨ tsoŋ21-jɑw51 **k^{h}**aj55 ts^{h}u55-laj35

'The car has to be out anyway.' → (meaningless)

In example (7a), the velar stop [k^{h}] is anticipated and substituted for the dental affricate [ts], showing a case where a dental stop is replaced by a velar consonant phone.

(7b) **Velar → Dental**

I: k^{h}ow21-xoŋ35 tow55 **t^{h}**u35 tswej51 xoŋ35-tɤ →

lipstick always paint most red

E: **t^{h}**ow21-xoŋ35 tow55 **t^{h}**u35 tswej51 xoŋ35-tɤ

'(she) always painted the lipstick with the most red color' → (meaningless)

In example (7b), the dental stop [t^{h}] is anticipated and substituted for the velar stop [k^{h}], showing a case where a dental stop is substituted for a palatal consonant phone.

(8a) **Dental → Retroflex**

I: mɔ35-t^{h}wɔ55-**tʂ^{h}**ɤ55 →

motorcycle

E: mɔ35-**tʂ^{h}**wɔ55-**tʂ^{h}**ɤ55

'motorcycle' → (meaningless)

In example (8a), the retroflex affricate [tʂ^{h}] is anticipated and substituted for the dental stop [t^{h}], showing a case where a dental stop is replaced by a retroflex consonant phone.

(8b) **Retroflex → Dental**

[2] The retroflex sounds are entirely being lost and therefore are replaced by the dental sounds in this speaker's phonological system.

I: kʰaj55-tʂɤ tʂʰɤ55-tsɨ tow55-foŋ55 →

drive car show around

E: kʰaj55-tʂɤ tɤ55-tsɨ tow55-foŋ55

'to drive the car showing around' → (meaningless)

In example (8b), the dental stop [t] is anticipated and substituted for the retroflex affricate [tʂ], showing a case where a dental stop is substituted for a retroflex consonant phone.

(9) **Palatal → Bilabial**

I: pu35 ʂɨ51 tʂu51-tɕja55-la →

not is residence

E: pu35 ʂɨ51 tʂu51-pa55-la

'(it) is not for residence' --> (meaningless)

Unlike the above case, in my corpus there is no such case in which a bilabial is replaced by a palatal phone. In this example, the bilabial stop [p] is perseverated and substituted for the palatal stop [tɕ], showing a case where a palatal affricate is replaced by a labial consonant phone.

(10a) **Bilabial → Velar**

I: jɛ21 pu51 ɕi21-xwan55 ta21 tjɛn21 ɕjɑw21 pʰaj35 →

also not like hit little small card

E: jɛ21 pu51 ɕi21-xwan55 ta21 tjɛn21 ɕjɑw21 xaj35

'(she) also doesn't like to play cards sometimes' --> (meaningless)

In example (10a), the velar fricative [x] is perseverated and substituted for the bilabial stop [p], showing a case where a bilabial stop is replaced by a velar consonant phone.

(10b) **Velar → Bilabial**

I: **p**u35-**ʂ**ɨ51 **k**u35-**p**ɑw21 →

not is castle

E: **p**u35-**ʂ**ɨ51 **p**u35-**p**ɑw21

'(this) is not a castle' --> (meaningless)

In example (10b), the bilabial stop [p] is either anticipated or perseverated, and substituted for the velar stop [k], showing a case where a velar stop is replaced by a labial consonant phone.

(11) **Palatal → Velar**

I: ts^{h}wan55 **x**wɑŋ35 k^{h}a21-**t**ɕi55 →

wear yellow Khaki

E: ts^{h}wan55 **x**wɑŋ35 k^{h}a21-**x**wi55

'to wear yellow pants (Khakis)' --> (meaningless)

Again, in my corpus, there is no case in which a velar is replaced by a palatal phone. In this example, the velar-glide sequence [xw] is perseverated and substituted for the palatal affricate [tɕ], showing a case where a palatal stop is replaced by a velar consonant phone.

The observed statistic differences presented here are in favor of the predicted asymmetries between dentals and other places of articulation, but no bias exists between labials and velars. This suggests a special status for ([+anterior]) coronals since they show a bias for replacement by other places of articulation. The difference is as predicted by underspecification, and is also confirmed by the findings shown in the research involving slips of the tongue in English.

The findings of this aspects of the research are summarized as follows:

(1) When a single target unit of a consonant is replaced by the source unit at the same place of articulation, 39% of the errors show that a dental sound is replaced by another dental sound; 25% of the errors show that a bilabial sound is replaced by another bilabial sound; 24% of the errors show that a palatal sound is replaced by another palatal sound; and merely 12% of the errors show that a velar sound is replaced by

another velar sound. This suggests that the unmarked coronals (the dental sounds) tend to be involved with high rates of substitution errors.

Table (4)

Substitution	**N**	**Substitution**	**N**	***P***
Dental → Bilabial	90	Bilabial → Dental	50	0.02 (<0.05)
Dental → Palatal	30	Palatal → Dental	15	0.01 (<0.05)
Dental → Velar	125	Velar → Dental	35	0.00 (<0.05)
Dental → Retroflex	40	Retroflex → Dental	35	n.s.
Bilabial → Palatal	0	Palatal → Bilabial	3	n.s.
Bilabial → Velar	30	Velar → Bilabial	25	n.s.
Velar → Palatal	0	Palatal → Velar	3	n.s.

(2) When a single target unit of consonant is replaced by another source unit at a different place of articulation, there is an asymmetrical behavior between the dentals and other places of articulation. Dentals show a great deal of statistically significant difference to be replaced by other places of articulation, but there is no bias between labials or velars, suggesting the underspecified value of ([+anterior]) coronals in the phonological system.

4.2 Palatalization

Evidence from diachronic analyses suggests that some palatals are historically derived from the velars. However, other evidence has suggested to some researchers that the palatals are synchronically related to the dental sibilants, and still others treat palatals as underlying phonemes. In the following, the set of obstruents which have been hypothesized to alternate with palatals will be referred to as 'palatal alternates', hereafter 'PAs' throughout the whole section of this paper.

The following issues were addressed based on the data from syntagmatic phonological errors in the Mandarin slips corpus.

alternation, as exemplified in (13b). No velar-palatal interaction is present.

(13a) I: tsɨ35-jow21 i55 tsoŋ21 jɛn35-sɤ51 →

only one kind color

E: tsɨ35-jow21 i55 tsoŋ21 jɛn35-ɕi51

'(there is) only one color' → (meaningless)

(13b) I: tsu21 i55 wan21 y51-mi21 t^hɑŋ55 →

cook one bowl corn soup

E: tɕy21 i55 wan21 y51-mi21 t^hɑŋ55

'to cook a bowl of corn soup' → (meaningless)

In (13a), the palatal vowel [i] is substituted for [ɤ], and the preceding dental consonant [s] changes to [ɕ]. In (13b), the palatal vowel [y] is anticipated and substituted for [u], and the preceding retroflex consonant [tʂ] changes to the palatal [tɕ].

In five errors, a larger unit (GVX) beginning with a glide [j, ɥ] is substituted for a rhyme, causing the preceding PA consonant to change to a palatal. These five cases all involve dental-palatal alternation, as shown below.

(14) I: **jow**35 swɔ21 $tɕ^h$**jow**35 →

have so ask

E: **jow**35 ɕ**jow**21 $tɕ^h$**jow**35

'have a favor to ask' → (meaningless)

In (14), the larger unit [jow] is either perseverated or anticipated and is substituted for the rhyme [wɔ], and [s] changes to the palatal [ɕ].

In summary, of these 61 errors, in 54 cases the dental changes to a palatal when the vowel [i, y] or glide [j, ɥ] is substituted or added after it. Seven cases show a retroflex-palatal interaction. There is no evidence to support the velar-palatal interaction; however, one could predict that if the vowel [i, y] or glide [j, ɥ] were added

(1) What happens to an initial PA consonant when the vowel [i, y] (which will be referred to as 'palatal vowel'), or glide [j, ɥ] (which will be referred to as 'palatal glides') is substituted or added after it? Does the initial consonant change to a palatal?
(2) What happens to a palatal consonant when a palatal vowel or glide is omitted after it? Does it change to dental, retroflex or velar, or does it remain palatal?
(3) Do palatals interact mainly with other palatals, or with dentals, retroflexes or velars? Do they typically involve palatal environments?

Turning to question 1, there are 24 errors involving the addition of a glide after PAs. In 20 cases, when the glide is added after the dental affricate [ts], [ts] changes to the palatal [tɕ], as exemplified in (12a), while in 4 cases, the retroflex affricates [tʂ] changes to [tɕ] when the glide [j] is added, as exemplified in (12b). There were no cases where a palatal glide is added after a velar consonant. (Note that in every case the source segment retains its manner and aspiration features).

(12a) I: min35-t^{h}jɛn55 i51 ts͡aw21 →

tomorrow one early

E: min35-t^{h}jɛn55 i51 **tɕj**aw21

'tomorrow early morning' → (meaningless)

(12b) I: **j**ow21 ʈʂ͡aw51 ʂaŋ51 lu51 →

have license up road

E: **j**ow21 **tɕj**aw51 ʂaŋ51 lu51

'driving with license' → (meaningless)

In example (12a), the palatal [j] is perseverated and added after the dental affricate [ts], and [ts] changes to the palatal [tɕ]. In (12b), the palatal [j] is perseverated and added after the retroflex affricate [tʂ] which changes to [tɕ].

In 32 errors, a palatal vowel [i, y] is substituted for a non-palatal vowel following a PA, and the preceding consonant changes to a palatal. Twenty-nine cases show a dental-palatal alternation, as exemplified in (13a), and 3 cases show a retroflex-palatal

after a velar, the velar would also change to the palatal. These findings do not support the claim that the palatals are allophones of any particular phoneme, but rather support an analysis in which there is a phonological rule whereby the dentals, retroflexes, and possibly velars are palatalized before a high front vowel or palatal glide and thus support the phonetically motivated neutralization of the dental/retroflex/velar distinction in the palatal environment. However, these numbers suggest somewhat more affiliation between palatals and dentals than the other two places of articulation. In addition, as noted above, whenever a dental/retroflex changes to a palatal, both dental/retroflex and palatal share the same manner of articulation and aspiration (i.e. [s]/[ʂ] →[ɕ], [ts]/[tʂ] → [tɕ], or [ts^h]/[tʂ^h] → [tɕ^h]). This may account for why there is less velar-palatal interaction found in these types of errors in my corpus, since if a velar were to change to a palatal, in two of three cases it would also need to change its place and manner of articulation, which would add more complexity in these types of errors: [k] → [tɕ], or [k^h] → [tɕ^h]. However, the alternation [x] → [ɕ] might be expected to occur since only the place feature changes, and yet no errors of this type were found.

Turning to question 2, there are 32 errors involving the omission of a palatal glide after a palatal obstruent. In all cases, when the palatal glide is removed, the palatal changes to a dental, as exemplified below.

(15) I: pi21 tɕ**j**ɑw51 tɕjow21-->
than more long
E: pi21 tɕ**j**ɑw51 **ts**ow21
'longer' → (meaningless)

In example (15), the palatal [tɕ] changes to [ts] when the glide [j] is deleted.

Sixteen errors involve a non-palatal vowel being substituted for a palatal vowel after a palatal consonant. When a non-palatal vowel is substituted, the palatal always changes to a dental, as exemplified in (16).

(16) I: sɨ51 tɕjɛn55 tɕy35 **u**55 →
is CL orange house

E: sɨ51 tɕjɛn55 **tsu**35 **u**55

'(this) is an orange house' → (meaningless)

In example (16), the non-palatal vowel [u] is anticipated and substituted for the palatal vowel [y], and the palatal changes to a dental.

Another 17 errors involve the substitution of a rhyme which begins with a non-palatal vowel or glide, for a rhyme which followed a palatal consonant. In all 17 cases, the preceding consonant changes to a dental, as exemplified below.

(17) I: pu35 ʂɨ51 tɕjɑw55 twɔ55 →

not is teach much

E: pu35 ʂɨ51 tswɔ55 twɔ55

'not teach very much?' → (meaningless)

In example (17), when the rhyme [wɔ] is substituted for the sequence [jɑw], the palatal [tɕ] changes to the dental [ts].

In all 65 errors discussed so far, when the palatal environment is removed, the palatal consonant is produced as a dental. There is one possible counterexample in my data, presented in (18).

(18) I: wɔ21 tɕjow51 tɕjɑw51-ɕyn51 t^ha55 →

I then punish him

E: wɔ21 tɕjow51 **k**ɑw51-ɕyn51 t^ha55

'I then punished him' → (meaningless)

This is analyzed as a non-contextual substitution of /k/ for [tɕi]. One possible explanation might be that the glide [j] is deleted in the context of the preceding [j], and the palatal is realized as a velar. However, it could also be that the single consonant [k] is substituted for the whole consonant-glide sequence [tɕj].

In summary, it seems that the palatals are closely linked with the dentals, since in

nearly every case when the palatal environment is removed, the palatal reverts to the dental. This could be evidence that palatals are allophones of dentals.

Looking at question 3, there are 141 syntagmatic phonological errors involving the substitution of one consonant for another, in which at least one of the segments is a palatal. In 90 errors, both target and source are palatal, as exemplified in (19).

(19) I: y21-jɛn35-ɕɥɛ35 t̪ɕjɛ51 →

linguistics field

E: y21-jɛn35-ɕɥɛ35 ɕ̪jɛ51

'the field of linguistics' → (meaningless)

In example (19), the palatal [ɕ] is perseverated and substituted for the palatal [tɕ] (although this could be considered a deletion of [t]) in the affricate [tɕ].

In 40 errors, a palatal interacts with a non-palatal consonant in a palatal environment, as exemplified in (20)[3]. Note that only consonants which are allowed before high front vowels or palatal glides are eligible for this error type, so this excludes PAs.

(20) I: jow21- tʂ-sɨ35-xow51 xwej51 xən21 pu51 ɕjɑŋ21 n̪jɛn51-su55 -->

sometimes will very not want study

E: jow21- tʂ-sɨ35-xow51 xwej51 xən21 pu51 ɕjɑŋ21 ɕ̪jɛn51-su55

'sometimes I really don't want to study' → (meaningless)

In example (20), the palatal [ɕ] is perseverated and substituted for a dental nasal [n]; note that in the intended utterance, [ɕ] and [n] are both allowed before the palatal [j].

However, there are 11 cases in which it appears that a palatal target is replaced by a non-palatal source from a non-palatal environment, or vice versa. In 10 cases the palatal interacts with a dental and in the other with a retroflex; in all cases, it causes a change in the vowel in the target word.

[3] Again, examples (20-21) are recorded from the same speaker, and the retroflex sounds are entirely

(21) I: tjɛn51 tɕi55 pwɔ35 s̱i51 pan55 -->

Electrical Eng Ph.D.

E: tjɛn51 tɕi55 pwɔ35 ɕi51 pan55

'Ph.D. program in the department of electrical engineering' → (meaningless)

(22) I: koŋ55-tswɔ51 tɕi55- xwej51 -->

job chance

E: koŋ55-tswɔ51 ts̱i55- xwej51

'job opportunity' → (meaningless)

In (21), one could argue that the fricative [ɕ] from the affricate [tɕ] is perseverated and substituted for the dental [s], and causes the change in the vowel. One could analyze (22) as a case, where the dental [s] from the affricate [ts] is perseverated and substituted for the palatal [ɕ], causing the vowel [i~ɨ] alternation. These errors look like they could be used to argue against the dental and palatal deriving from the same underlying segments, since by definition, one allophone of a phoneme cannot be substituted for another. However, in fact, these can be analyzed as a case where the place feature value has been erroneously spread from one onset consonant to the other, causing the vowel to change to its correct alternant. In (21), I argue that the palatal value from [tɕi] has been erroneously applied to [s̱i]. In example (22), the dental value of the onset of [tswɔ] has been erroneously copied into the onset of [tɕi]. An alternative explanation of (22) would be that the palatal feature has been omitted, causing it to revert to the dental value. Either of these interpretations fit well with the general model I will present below; since mainly dentals are involved in this type of error, this reaffirms the close link between dentals and palatals in Mandarin.

In summary, I find that in substitution errors, the palatals mainly interact with other palatals or non-PA-consonants which can occur in the palatal environments. There are a few errors in which a palatal seems to interact with a PA; however, I have

being lost and therefore are replaced by the dental sounds in the speaker's phonological system.

argued that these are better analyzed as feature errors. One might argue that in my data, since there are no cases where the velar is substituted for the palatal, this suggests that the velars and palatals are the same phoneme; however, other evidence shows a stronger affiliation between the dentals and palatals.

The findings of this section are summarized as follows:

(1) In 61 errors, there are 54 cases in which a dental changes to a palatal when the vowel [i, y] or glide [j, ɥ] is substituted or added after it; seven cases show a retroflex-palatal interaction. There is no evidence to support the velar-palatal interaction; however, one might predict that if the vowel [i, y] or glide [j, ɥ] were added, a velar would also change to a palatal.

(2) There are 65 errors in which the palatal environment is removed after a palatal consonant; in all cases the palatal is realized as a dental. Only one non-contextual error shows the palatal changing to a velar. Thus when the palatal environment is removed, the palatal changes to a dental consonant in every contextual error.

(3) In 141 syntagmatic errors involving substitution of palatals, the palatals mainly interact with other palatals or non-PA-consonants which can occur in palatal environments. Eleven errors show a palatal interacting with a PA consonant; however, these errors are better analyzed as featural errors. In these 11 cases, ten involve dental-palatal alternation, and one involves retroflex-palatal alternation, with no cases of velar-palatal alternation present. Taken altogether these errors demonstrate a close relationship between dentals and palatals.

Based on these findings, one might also suggest that dentals and palatals are in allophonic variation. This would support Hartman's (1944) and Hockett's (1947, 1950) analyses that palatals are the palatalized allophones of dental phonemes. However, this does not explain the interaction between the retroflexes and palatals in the speech-error data. Therefore, traditional phonemic theory may not be able to fully explain the findings from the external evidence.

A more explanatory proposal comes from underspecification theory and neutralization. Paradis and Prunet (1991) have concluded that ([+anterior]) coronal consonants are different from labials and dorsals in that as a principle of grammar they lack the Place Node. They suggest that the coronals (dentals and alveolars) are underspecified for place, since the overt presence of the [+coronal] value required on

the surface can be left unspecified underlyingly and be provided by a default mechanism. Therefore, in Mandarin, one could suggest that surface dentals and palatals are derived from the same underlying segment units, which are unspecified for place underlyingly; in normal production, if these affricates/fricatives are followed by [i, y, j, ɥ], they get their place feature from the vowel. If they are followed by other vowels or glides, they get the default [+anterior] value (which is inherently [+coronal]). In errors the same process occurs, so if the palatal environment is added or taken away, place features are assigned to the new erroneous string according to the same process. This accounts for the dental-palatal alternation. On the other hand, the fact that retroflexes (and probably velars) are realized as palatals when erroneously placed before palatal glide is due to the strict co-occurrence constraints between onsets and nucleus elements in Mandarin. In this case, the constraints cause a neutralization of the place contrast before palatals. Vowels which are [+high, -back] can be considered to have the analogous place features as [+palatal] consonants. The palatalization process then can be viewed as either a spreading of the relevant feature from a nucleus to a segment unspecified for that feature, or a changing of the feature value on segments which find themselves adjacent to a high front vowel or glide, in violation of this constraint. The constructs of underspecification, neutralization, and palatalization fully account for these findings.

The present data can be interpreted as supporting the following processing model. First, in underlying representations, there is a single segment, unspecified for place, which will surface as either a dental or palatal consonant depending on context. Consonants are represented in terms of features linked to a C-node; similarly the affricates are unified under a C-node. When the phonological representations of words are inserted into their syntagmatic slots, phonological errors of movement, substitution, addition and omission occur, with segmental nodes being the primary unit of error.

In Mandarin, the error phenomena involve the interaction of coronals with other places of articulation. It has shown that there are systematic biases, such that dentals tend to be interacted more often than any other places of articulation (including marked coronals) and that dentals tend to be involved with high rates of substitution errors. Coronals behave in a special manner in language performance errors, and phonological

underspecification of place features appears to be the best explanation for this special behavior. However, the empirical evidence from neurolinguistics and language acquisition has not been fully verified yet; therefore the theory of underspecification of coronals in Mandarin is needed for more psycholinguistic and neurolinguistic evidence addressed here.

References

Archangeli, D. 1988. Aspects of underspecification theory. *Phonology* 5.2:183-207.

Avery, P. & K. Rice. 1989. Segment structure and coronal underspecification. *Phonology* 6.2:179-200.

Bock, K. & W. Levelt. 1994. Language production: grammatical encoding. *Handbook of Psycholinguistics,* ed. by M. Gernsbacher, 945-984. San Diego: Academic Press.

Chao, Y- R. 1934. The non-uniqueness of phonemic solutions of phonetic systems. *Bulletin of Institute of History and Philology*. Academia Sinica 4.4:363-397.

-----. 1968. *A Grammar of Spoken Chinese*. Berkeley: University of California Press.

Chen, J.Y. 1999. The representation and processing of tone in Mandarin Chinese: Evidence from slips of the tongue. *Journal of Applied Psycholinguistics* 20: 289-301.

Chen, S. Y. 1996. *A Theory of Palatalization and Segment implementation.* Ph.D. dissertation. SUNY-Stony Brook.

Cheng, C. C. 1973. *A Synchronic Phonology of Mandarin Chinese*. The Hague: Mouton.

Chomsky, N. & Halle, M. 1968. *The Sound Pattern of English*. New York: Harper and Row.

Clements, N. 1985. The geometry of phonological features. *Phonology* 2:225-252.

Dell, G. 1984. The representation of serial order in speech: Evidence from the repeated phoneme effect in speech errors. *Journal of Experimental Psychology: Learning, Memory & Cognition* 10:222-233.

Duanmu, S. 1990. *A Formal Study of Syllable, Tone, Stress, and Domain in Chinese Languages*. Ph.D. dissertation. MIT.

Fromkin, V. (ed.). 1973. *Speech Errors as Linguistic Evidence*. The Hague: Mouton.

Goldsmith, J. 1976. *Autosegmental Phonology*. Ph.D. dissertation. MIT. NY: Garland Press, 1979.

Hall, T. A. 1997. *The Phonology of Coronals*. Amsterdam: John Benjamins Publishing Company.

Hartman, L. M. 1944. The segmental phonemes of the Peiping dialect. *Language* 20: 28-42.

Hockett, C. F. 1947. Peiping Phonology. *Journal of the American Oriental Society* 67: 211-222.

-----. 1950. Peiping morphophonemics. *Language* 26: 63-85.

Hsueh, F. S. 1985. *Guoyu yinxi jiexi (An anatomy of the Pekingese sound system)*, Student Book Co, Ltd., Taipei.

Keating, P. 1991. Coronal places of articulation. *The Special Status of Coronals:*

Internal and External Evidence, II: Phonetics and Phonology, ed. by C. Paradis & J-F. Prunet, 29-47. San Diego: Academic Press.

Levelt, W. 1989. *Speaking: From Intention to Articulation*. Cambridge, MA: MIT Press.

Lin, Y. H. 1989. *Autosegmental Treatment of Segmental Process in Chinese Phonology*. Ph.D. dissertation. University of Texas at Austin.

Maddieson, I. 1987. *Patterns of Sounds*. Cambridge University Press, Cambridge, England.

Mester, R. A. & J. Ito. 1989. Feature predictability and underspecification: Palatal prosody in Japanese Mimetics. *Language* 65.2:258-293.

Paradis, C. & J-F. Prunet. 1991. Introduction: Asymmetry and visibility in consonant articulations. *The Special Status of Coronals: Internal and External Evidence, II: Phonetics and Phonology,* ed. by C. Paradis & J-F. Prunet, 1-28. San Diego: Academic Press.

Pulleyblank, D. 1983. Vowelless Chinese? An application of the three tiered theory of syllable structure to Pekingese. *Paper for the XVI international conference on Sino-Tibetan languages and linguistics,* at University of Washington.

Shattuck-Hufnagel, S. 1986. The Representation of phonological information during speech production planning: Evidence from vowel errors in spontaneous speech. *Phonology-Yearbook*. 3. 117-149.

Spencer, A. 1997. *Phonology*. Cambridge, MA: Blackwell. 125-126.

Stemberger, J. 1983. *Speech Errors and Theoretical Phonology: a Review*. Indiana University Linguistics Club.

-----. 1991. Radical underspecification in language production. *Phonology* 8: 73-112.

-----. 1992. Vocalic underspecification in English language production. *Language* 68.3:492-524.

Stemberger, J. & C. Stoel-Gammon. 1991. The underspecification of Coronals: Evidence from language acquisition and performance errors. *The Special Status of Coronals: Internal and External Evidence, II: Phonetics and Phonology,* ed. by C. Paradis & J-F. Prunet, 181-197. San Diego: Academic Press.

Tse, J. K. 2000. The perceptual saliency of palatality, dentality, and retroflexion in Mandarin consonants: An experimental study. *Studies in English Literature and Linguistics* 26:97-112.

Tung, T. H. 1954. *Zhongguo yuyin shi (A phonological history of Chinese)*. Taipei.

Wan, I. P. 1997. The status of prenuclear glides in Mandarin Chinese: Evidence from speech errors. *Chicago Linguistics Society* 33:417-428.

-----. 1999. *Mandarin Phonology: evidence from speech errors*. Ph.D. dissertation. SUNY-Buffalo.

-----. 2000. Testing the Psychological Reality of Coronals. *Proceedings of the 2000 NCCU Teachers' Conference on Linguistics Research*, 66-93. National Chengchi University.

-----. 2001. On the Representation and Processing of Prenuclear Glides in Mandarin. *Proceedings of the 7th International and the 19th National Conferences on Chinese Phonology*, 232-248. National Chengchi University.

-----. 2002. Feature Theories from a Cognitive Perspective. *Proceedings of the 1st Cognitive Linguistics Conference*, 172-198. National Chengchi University.

Wan, I. P. & J. Jaeger. 1998. Speech errors and the representation of tone in Mandarin Chinese. *Phonology* 15: 417-461.

Wu, Y. 1994. *Mandarin Segmental Phonology*. Ph.D. dissertation. University of Toronto.

[Received 25 February, 2002; revised 27 May, 2002; accepted 1 June, 2002]

Graduate Institute of Linguistics
National Chengchi University
Taipei, TAIWAN
ipwan@nccu.edu.tw

由語誤例證來探討漢語子音發音部位非對稱現象

萬依萍

國立政治大學

本文旨在透過認知的驗證來探討一個語音系統內特殊的現象。此現象即爲([+anterior]) coronal 的語音部位在西洋的底層音韻結構內並不需被標記的。也就是說在發音的位置上，coronal 會產生與其他發音位置不對稱的情形。本文是利用 3500 筆的漢語語誤語料來作確認的工作。結果發現漢語使用者在語言線上傳導模型中的確對於 coronal 這個語音部位有特殊偏好。

關鍵詞: 語誤、語言模型、音韻理論