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Speech Errors of Tone in Taiwanese

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In this study, we analyze tone errors of Taiwanese spontaneous speech to tackle three issues. The first is to make a comparison between segmental errors and tone errors in Taiwanese to see if these two kinds of errors behave similarly. The second is to investigate the role of language-specific tone rules in the occurrence of tone errors. Taiwanese, with a unique and complex tone sandhi phenomenon, provides a good ground to examine this issue. The third issue is to investigate the mechanism of Taiwanese tone sandhi phenomenon. Consider the first issue. The results showed that tone errors and segmental errors have similarities as well as differences. Second, our study showed that language-specific tone rules play an important role in the occurrence of tone errors. Moreover, regarding the mechanism of the tone sandhi phenomenon, our results seemed to support the allomorph-selection model better.

0. Introduction

Analysis on speech errors provides different evidence to investigate the grammar of speech production, the reality of phonological rules as well as processes, and the psychological reality of phonological units, syllable structures, etc.. However, most of the previous studies on speech errors deal with Indo-European languages such as Dutch, German, and English. There are much fewer research studies on non-Indo-European languages which have different language systems such as Thai (Gandour 1977), Arabic (Hassan and Issam 1987), and Chinese (Shen 1993, Chen 1999, Wan 1999, 2007a, b). Moreover, most of the phonological studies focus on consonants and vowels, i.e. segmental errors. Researches on suprasegmental errors such as tonal errors are practically rather scant due to this Indo-European bias. Accordingly, this study of tone errors in Taiwanese not only contributes to the study of tone, but also provides one more set of data of non-Indo-European languages to the study of speech errors.

1. Literature Review

Compared with studies on other phonological components such as consonants and vowels, the study on tone is really scarce. There are only one study on Thai (Gandour 1977) and some on Mandarin (Wan 1999, 2007a, b). Gandour (1977) is the first one to show that lexical tone, like other phonological components, also has errors. His study on tone errors of Standard Thai produced by Phuket Thai bidialectals showed that tone errors behave similarly to segmental errors. First of all, tone errors do not occur

randomly. Instead, they are context-conditioned, which means that we can find the interference source of an error in the utterance. Like segmental errors, tone errors can be analyzed properly according to the direction of the error source in the context. Regarding the directionality, perseverations exceed anticipations in Thai tone errors in a ratio of about 2 to 1. This pattern is opposite to that of segmental errors found in other studies (Fromkin 1973, Cohen 1973, Nooteboom 1973) which show that anticipations outnumber perseverations. Moreover, Gandour found that in addition to context factors, the factor of language-specific tone rules also plays a role in the occurrence of tone errors. Nevertheless, context is still the major factor.

Wan made a series study on Mandarin phonological errors, including segmental errors and tone errors (Wan 1999, 2007a, b). She had the same conclusion as Gandour that tone errors and segmental errors behave similarly regarding the directionality and error source. However, concerning dialectal interference and the influence of language-specific tone rules, Wan had different claims from Gandour. Wan's study on Mandarin showed that there is little dialectal interference and no influence of language-specific tone rule on the occurrence of tone errors in Mandarin.

2. Purpose of Study

There are three purposes in this study. The first purpose is to make a comparison between tone errors and segmental errors collected from the same corpus. Gandour and Wan concluded that tone errors behave similarly to segmental errors in that both are mainly context-conditioned and can be accounted for by the directionality of error source. Regarding the term 'context-conditioned' used in segmental errors, there are several meanings. First, segmental errors do not occur at random (Fromkin 1973, Gandour 1977, Wan 1999). Most of the time, we can find the source of interference in the utterance. Second, some context factors constrain or facilitate the occurrence of segmental errors such as distance and phonological similarity between the target and the source words. Cohen (1973) and Nooteboom (1973) found that the distance between the error and the source words in segmental errors are mainly within seven syllables. In addition, the number of errors and the distance between the error and the source words bear an inverse relationship, the longer the distance between the error and the source, the fewer the tokens. Moreover, in segmental errors, the target and source words usually have phonological similarity, such as similar syllable structure, stress pattern, or same segmental components (Boomer and Laver 1973, Nooteboom 1973, Wan 1999). In this study we will make a comparison between tone errors and segmental errors via the three aspects to see if they have similar behaviors, i.e. the directionality of error source, the distance between the error and the source words (hereafter the E-S distance) and the phonological similarity between the target and source words (hereafter the T-S similarity).

The second purpose is to investigate the factor of language-specific tone rules on tone errors. Gandour (1977) found that the factor of language-specific tone rules

contribute to some tone errors in Thai while Wan (1999) mentioned that there is no influence of the Mandarin tone sandhi rule on tone errors. Hence, the influence of language-specific factors is not so clear and it needs further research to show if language-specific tone rules are a factor contributing to tone errors. Actually, compared with Standard Thai and Mandarin, Taiwanese provides a better ground to investigate the influence of language-specific rules on tone errors. In Standard Thai, there is no language-specific tone rule per se. The influence of language-specific tone rules Gandour found is due to the dialectal interference of Phuket Thai, which is the subjects' mother tongue.

As to Mandarin, although both Mandarin and Taiwanese are sub-languages of Chinese and both have tone sandhi phenomenon, the tone sandhi phenomenon in these two languages are essentially different. First, in Mandarin, there is only one tone sandhi rule applying to one tone while the tone sandhi phenomenon in Taiwanese is composed of a set of tone sandhi rules applying to every tone. Second, the Mandarin tone sandhi rule applies according to the word following the target in the utterance. Hence, the environment of rule application is also a context-conditioned factor. However, the tone sandhi phenomenon in Taiwanese is much more complicated. Every tone has two realizations, occurring on the surface according to the position of the target in the utterance which is syntactically defined and irrelevant to the segments surrounding the target. Consequently, different from the tone sandhi rule in Mandarin, the tone sandhi rules in Taiwanese are not context-conditioned. Accordingly, due to the unique and complex tone sandhi phenomenon, Taiwanese is a good candidate to investigate the issue whether language-specific tone sandhi rules are a factor contributing to the occurrence of tone errors or not. Moreover, the mechanism of Taiwanese tone sandhi phenomenon is still under debate. Hence we would like to assess different models accounting for this phenomenon based on our error data.

3. Tonal System In Taiwanese

Taiwanese is a dialect of Southern Min spoken in Taiwan. There are seven tones in Taiwanese, including five long tones and two short tones. Every tone has two realizations. One is called "citation tone" and the other is called "sandhi tone", as illustrated in Table 1. The notation of the tone value adopts Chao's (1930) five-point system, in which '5' indicating the highest pitch, '3' middle and '1' lowest.

The citation tone occurs in isolation as well as boundary position of a tone group while the sandhi tone occurs in a non-boundary position of a tone group. The tone group is a syntactically defined phrase (see Chen 1987, for detailed discussion on tone grouping and tone sandhi environments). Basically, a lexical item appears with sandhi tone when followed by another lexicon which is within a tone group. Take the word [si11] 'four' for example. When it occurs alone, it appears with the realization [si11]. When it is followed by another lexical item such as [tsap5] 'ten', it appears with the sandhi tone as [si53-tsap5] 'forty'

Table 1 Tone inventory of Taiwanese

Citation tone	Sandhi tone	Gloss
si55	si33-kua55	'poem'
si53	si55-kau53	'dead dog'
si11	si53-tsap5	'forty'
si33	si11-biə33	'temple'
si13	si33-tsit3	'quit job'
sik3	sik5-tsui53	'color'
sik5	sik1-sai33	'know'

The mechanism of the tone sandhi phenomenon in Taiwanese is still under debate. Traditionally, it is assumed that these two tone realizations bear a generative relation of rule application (Wang 1967, Cheng 1968). The basic idea of this rule-application model is that the base tone, i.e. the citation tone, is stored in the lexicon as an underlying form. The sandhi tone is derived from the base tone via the application of a set of tone sandhi rules, which are formulated in (1). The left side of the arrow indicates base tones while the right side of the arrow indicates sandhi tones. Notice that the derivation is unidirectional. Only the sandhi tone can be derived from the citation tone but not vice versa.

(1) 55 →33
13 →33
53 →55
11 →53
33 →11
5 → 1
3 → 5

However, later studies (Hsieh 1970, Wang 1983, Tsay and Myers 1996) casted strong doubt on the psychological reality of the formulated tone sandhi rules as well as the derivation process. Those experiments were conducted by asking subjects to generate the sandhi tone of a given citation tone.

Hsieh's (1970) experiment results showed 100% accuracy rate of the citation tones on the one hand and on the other hand, low accuracy rates of sandhi tones, along with low proportions of wrong application as well as high proportions of non-application of the tone sandhi rules. Meanwhile, different tone sandhi rules exhibit different degrees of accuracy rate. Based on the experiment results, Hsieh (1970) argued against the psychological reality of the rule-derivation model and further proposed an alternative model to account for the tone sandhi phenomenon. The basic ideas are that all surface

forms of a lexical item exist in the mental lexicon and the appearance of the surface tone depends on the selection of the allomorphs according to the position of this lexical item in an utterance. Hence, different from the derivation model, there are no so-called tone sandhi rules as well as rule-application process in the list hypothesis.

Wang (1983) also showed non-application errors of sandhi tones and inconsistency of the accuracy rates among different tone sandhi rules. Moreover, the results showed that the accuracy of sandhi tones can be improved via practice, supporting Hsieh's claim that familiarity plays a role in the selection process. Tsay and Myers (1996) argued that Taiwanese tone sandhi phenomenon is an example of lexical phrasal phonology. Both citation form and sandhi form of a lexical item co-exist in the mental lexicon. The occurrence of a given tone on the surface is a process of allomorph selection rather than allomorph generation. Though there are differences among those researchers' viewpoints, the main idea of them is that the occurrence of the surface tone of a lexical item is a process of selection or analogy rather than a process of rule derivation. Hence, we give this alternative model a general name as the allomorph model.

4. Methodology

In this study, speech errors, also called slips of the tongue, are defined as one-time errors in speech production planning. An intended utterance, which is usually a word but can also be a phrase or even a proposition, is mispronounced due to something going wrong in the planning process. Hence, errors such as repetition or repairment due to change of the topic or hesitation are excluded. Most of the time, the speakers are aware of these tongue slips made by themselves and will correct them right away. If the speakers do not notice or correct the errors, the listeners will remind them or make a correction on the errors. The data source of this study is recordings of Taiwanese spontaneous speech collected from radio programs. Most of the programs were conducted by a host and a hostess. They were native speakers of Taiwanese. In addition to the hosts and hostesses, the subjects also included different invited guests.

Errors of tone are classified based on the nature of the errors. Basically, our tone error data can be classified as the following five categories: phonological context errors, tone sandhi errors, non-context errors, lexical blends and language-mixing errors. Phonological context errors are errors in which we can find the error source in the utterance. If the source word precedes the error, it is a perseveratory error. If the source word follows the error, it is an anticipatory error. A phonological error can also be bidirectional when possible source words are found both before and after the error. An example of context errors is (2). In each of the following examples, the utterance is phonetically transcribed. The first line represents the phonetic transcription, the second line is a word-by-word gloss and the third line is an English translation of the intended utterance. The target word (intended utterance) is boldfaced. The source word (source of interference) is underlined. The error is boldfaced and underlined. Following the format and diacritics of CHILDES (MacWhinney 1995), the marker [//] indicates a marker of

repairment. The word before the marker [//] is the misarticulated error and the word after it is the correction. The marker {} indicates the boundary of the utterance which is repaired if it contains more than one word. The marker [*] indicates an error without correction. Moreover, the tone value of initial and final particles is marked as 0.

(2) u11 he55 {tsok5 se53 tiau53}[//] tsok5 se53 tiau13 e33 hui53-kŋ̩53
have that very tiny CL very tiny CL DE vessel
'There are very tiny blood vessels.'

In (2) the target tone [13] in [tiau13] 'a classifier' is mis-uttered as the tone [53]. There are two possible interfering sources. One is the word [se53] 'tiny' preceding the error and the other is the following word [hui53-kŋ̩53] 'vessel'. Hence this case is an anticipatory/perseveratory (hereafter A/P) error.

Tone sandhi errors specifically categorize tone errors in which there is a tone sandhi relationship between the error tone and target tone. The error is either the citation form or the sandhi form of the target. Non-context errors are errors in which we can not find the source in the utterance. Tone sandhi errors can be counted as non-context errors broadly because as mentioned previously, the realization of citation tone or sandhi tone are irrelevant to the surrounding segments in the utterance. However, we separate them from non-context errors for they are essentially different. Regarding non-context errors, we can neither find the source in the utterance nor find a possible source outside the context. As to the tone sandhi errors, we can find the error source though it is not in the context and we can give a reasonable explanation accounting for this kind of errors. Accordingly, we separate these two kinds of errors. Examples of tone sandhi errors and non-context errors are in (3) and (4), respectively.

(3) Tone sandhi errors
{lai33 po11} [//] lai33 po53 tɕit5 ɕiu55 kua55
come broadcast come broadcast this CL song
'Let's play this song.'

(4) Non-context error
tɕiam33-tui53 ba32 kha55 iu11 e33 po55-hun55 [*] lai33 su55ioŋ33
focus meat more tender DE part come use
'Only use the more tender part (of the mangoo in cooking).'
(intended target: po11-hun33)

In (3), the target tone [53] in the verb [po53] 'broadcast' is substituted by the tone [11]. On the one hand, the tone [11] is the corresponding citation tone of the sandhi tone [53]. On the other hand, there is no other syllable with the tone [11] in the utterance. Hence, this error is classified as a tone sandhi error, in which the sandhi tone is replaced

by the citation tone. In (4), the target tones [11] and [33] in the word [po11-hun33] are articulated as [55-55]. Since we can neither find a source in the utterance with the tone pattern [55-55] nor find other possible intervening source, we count it as a non-context error.

The last two error categories involving tone errors on the surface are lexical blends and language mixings. These two kinds of errors are lexical errors rather than pure phonological errors. A lexical blend involving tone error is a lexical error maintaining the syllable structure of the target word but substituting the tone with that of the source word. A language-mixing error involving tone is an erroneous combination of syllable structure of the target word and the tone of the Mandarin counterpart, which is a kind of bilingual interference. Examples of lexical blends and language-mixings are (5) and (6), respectively.

(5) gua55 u11 ka53 li55 koŋ33 [//] koŋ55-kue53 ten11-ue33.
I have with you talk talked telephone
'I had talked to you on the telephone.'

(6) lan55 e33 ten53 [//] ten11-ue33 ɕi11 koŋ53 ji33 …
we DE electric telephone is zero two
'Our telephone number is zero two …'

In (5), the error is a lexical blend of the target [koŋ55] 'talk' and the intervening source [thoŋ33] 'contact'. Both are verbs related to making a phone call and both verbs are used by this host frequently. As a result, the phonological similarity (both have the same rhyme '[oŋ]') as well as the semantic relatedness of these two words contribute to this error. In (6), it is a language-mixing error of the target word [ten11] 'electric' and its Mandarin counterpart [tien53].

5. Analysis of Tone Errors

A corpus of 159 tone errors are collected in our data. They are classified into six categories according to the factors causing the errors, as shown in Table 2.

Table 2 Classification of tone errors

Category	Type I Options	Type II T. sandhi	Type III Context	Type IV Non-cont.	Type V Lex. ble.	Type VI Lg. mixing	Total
Tokens	83	33	19	5	5	14	159
%	52.2%	20.8%	11.9%	3.1%	3.1%	8.8%	100%

Note: "T. sandhi" stands for tone-sadhi errors, "Non-cont." for non-context errors, "Lex. ble." for lexical blends, and "Lg. mixing" for language-mixing errors.

Type I 'Options' contains errors with more than one possible analysis, mainly analytical ambiguity between context errors and tone sandhi errors. In order not to distort the data by unconscious bias, we tentatively put those errors in this category 'Options'. It is clear that Type I 'Options' has the most error tokens, with a proportion more than 50%. This high proportion of ambiguity cases causes complexity in further analysis of tone errors and difficulty in hypothesis testing.

This table answers our second question clearly concerning the role of language-specific factor in the occurrence of tone errors. We can investigate this issue via two types of errors, i.e. Type I 'Optional errors' and Type II 'Tone sandhi errors'. Type II are errors of substitution between citation tones and sandhi tones. Hence, they are errors due to the influence of Taiwanese tone sandhi rules. If we only consider clear error tokens, then tone sandhi errors contain the most tokens, more than 40% (33 out of 76). As to Type I, though most of the errors can be analyzed as tone sandhi errors or context errors and we can not make a clear-cut distinction among these errors, it still implies that the tone sandhi rules play a role on the occurrence of tone errors. Accordingly, our data clearly show that the factor of language-specific tone rules definitely play a role in the occurrence of tone errors. In the following sections, we will make different analyses based on Table 2 to tackle our questions.

6. Comparison Between Tone Errors and Segmental Errors

According to Gandour (1977) and Wan (2007b), phonological tone errors behave similarly to segmental errors. In this section, we will make a comparison between tone errors and segmental errors to see if they behave similarly. The segmental errors adopted for comparison are collected from the same corpus. Since the comparison is between phonological errors, we only include phonological tone errors, and exclude data of lexical blends and language-mixing errors as well as optional errors involving lexical factors. Consequently, the errors included for comparison are only substitution errors of single segment or tone. There are 119 segmental errors and 81 tone errors adopted for comparison. The tone errors include 65 option errors in Type I and 16 context errors in Type III.

For easiness of comparison between tone errors and segmental errors, we tentatively treat those ambiguous tone errors in Type I as context errors (hereafter TI errors) but do not combine them with clear context tone errors in Type III (hereafter TIII errors). We make a comparison between these two types of tone errors and segmental errors to see if they have similar behaviors in some context factors. The comparison is conducted from three perspectives: directionality, the distance between the error and the source words (hereafter the E-S distance), and phonological similarity between the target and the source words (hereafter the T-S similarity).

Directionality

Table 3 shows the frequency of tone errors as well as segmental errors based on the direction of the error source.

Table 3 Frequency of phonological errors based on directionality

Phonological errors \ Direction	Per.	Ant.	A/P	Total
Segmental errors	24 (20%)	74 (62%)	21 (18%)	119
TI errors	28 (54%)	19 (29%)	19 (17%)	65
TIII errors	7 (44%)	3 (31%)	7 (25%)	16

Note: 'Per.' stands for Perseveratory errors, 'Ant.' for Anticipatory errors, and 'A/P' for Anticipatory/Perseveratory errors.

It is clear to see that tone errors, both TI errors and TIII errors, have different distribution patterns from that of segmental errors regarding the directionality of the error source. The former has more perseverations than anticipations while the latter has the opposite distribution. The pattern of perseverations exceeding anticipations in tone errors is consistant with the findings of Gandour (1977) and Wan (2007b). However, the pattern of segmental errors with more anticipations is contrary to Wan's (2007b) finding in Mandarin, in which both segmental and tonal errors have more perseverations than anticipations. But this pattern is consistent with the findings of most studies of segmental errors in Indo-European languages (Cohen 1973, Nooteboom 1973, Fromkin 1973, Berg 1987). In a word, regarding the directionality of the error source, tone errors behave different from segmental errors in Taiwanese.

The E-S Distance

The E-S distance indicates the span between the error and the source words, counted by syllables. If the error and the source are next to each other, the E-S distance is one syllable. Take an example in TI errors for illustration. In (7), the error is the word [koŋ53] 'broad' and the source word is the word [te53] 'short'. Hence, the E-S distance is four syllables

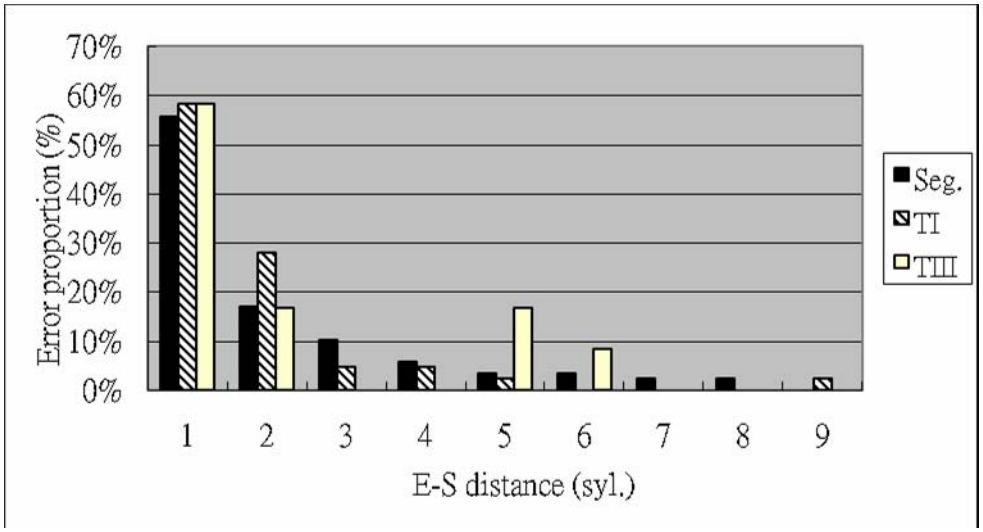
(7) in33-ui11 **koŋ53**-kə11 [//] **koŋ55**-kə11 ne0, te55-te53 ɕi33-kan55, ...
because broadcast broadcast PART short time
'Because the time of advertisement is quite short, …'

A frequency distribution of the E-S distance is shown in Table 4 and Figure 1. It only includes errors with one source word and errors with two source words in which both source words are equally distant from the error. Hence the tokens of segmental errors, TI and TIII errors are 88 errors, 43 errors, and 12 errors, respectively.

Table 4 Frequency of phonological errors based on the E-S distance (1)

Distance (syl.) / Tokens	1	2	3	4	5	6	7	8	9
Segmental errors	49	15	9	5	3	3	2	2	0
TI errors	24	13	2	2	1	0	0	0	1
TIII errors	7	2	0	0	2	1	0	0	0

Figure 1: Frequency of phonological errors based on the E-S distance (2)



In Figure 1, it shows clearly that segmental and tone errors behave similarly from the perspective of the E-S distance. First, errors with the E-S distance of 1 syllable have the highest ratio, more than 50%. That is, more than half of the phonological errors are caused due to the influence of the adjoining syllable. Moreover, the average E-S distance of segmental, TI and TIII errors are 2.2 syllables, 1.8 syllables and 2.3 syllables, respectively. They are similar to that of segmental errors found in Cohen (1973), Nooteboom (1973) and Wan (2007a, b), which are 2.1, 2.2 and 2.2 syllables, respectively.

Second, the proportion of error tokens is in reverse-proportion to the E-S distance. The longer the distance is, the fewer the errors occur. Third, the E-S distance of most errors does not exceed seven syllables. This finding provides an argument for the syllable as a unit in phonemic programming. Nooteboom (1973) suggested that the finding of the E-S distances usually within seven syllables can be explained by the limit span of the working memory span, which contains about seven units (Miller 1962). Thus, the finding can be interpreted as an argument for the syllable as a basic unit in the phonemic programming stage of speech planning.

The distribution patterns indicate that distance is a factor constraining the occurrence of phonological errors, both segmental and tonal.

The T-S Similarity

Next, consider the factor of T-S similarity. The T-S similarity is calculated by comparing the target and the source words based on the four phonological components of a lexicon, i.e. onset(O), vowel(V), coda(C) and tone(T). Each component is represented by a number with the value of 1 or 0. If the target and the source have one identical component, then the similarity is 1 point on that component, otherwise the value is 0. Therefore, the similarity factor is encoded by four numbers in sequence. The four numbers in sequence represent the sameness or difference between the target and the source words concerning the four phonological components onset, vowel, coda and tone (OVCT) respectively. The degree of similarity is the sum of the four numbers, ranging from 0 to 4.

Some examples in Table 5 illustrate the calculation of the T-S similarity. The first column of 'Error' indicates the error words. The second and third columns indicate the intended target and the error source, respectively. The similarity is calculated by comparing the target column and the source column.

Table 5 Similarity between the target and the source

Error	Target	Source	Similarity OVCT	Similarity degree
tsu13	su13	tsai33	0000	0
pau55	kau55	pa53	0100	1
k^hen55	ts^hen55	k^ha55	0001	1
kaŋ55	kan55	kaŋ55	1101	3

Take the first item in Table 5 as an illustration. The error is [tsu13], of which the target is [su13] and the error source is [tsai33]. There is no identical component between the target [su13] and the source [tsai33]. Therefore the similarity coding of OVCT is '0000'. The T-S similarity degree, i.e. the sum of the four numbers, is 0. In the second item, the target [kau55] and the source [pa53] have a common vowel [a]. Accordingly, the similarity coding of OVCT similarity is '0100', of which the second number '1' indicates the similarity of vowel between the target and the source words. The T-S similarity degree is 1. Likewise, the similarity coding of the third item is '0001' because the target [tshen55] and the source [kha55] have the same tone. The T-S similarity degree is 1. Hence, if an error has a similarity degree more than 0, it means that the target and the source words share some phonological similarity.

Table 6 lists the frequency distribution of segmental and tone errors with different similarity degrees. Only errors with one source word are included for the analysis of T-S similarity.

Table 6 Frequency distribution of the T-S similarity degree

Sim. degree / Error category	0	1	2	3	4	Total
Segmental errors	27 (32%)	40 (47%)	15 (18%)	0 (0%)	0 (0%)	85
TI errors	23 (59%)	15 (38%)	0 (0%)	0 (0%)	0 (0%)	23
TIII errors	5 (50%)	4 (40%)	1 (10%)	0 (0%)	0 (0%)	10

Table 6 shows that tone errors behave differently from segmental errors with regard to the factor of T-S similarity. In segmental errors, there are about 30% of tokens with a T-S similarity degree of 0. However, in tone errors, there are 50% of TIII errors and nearly 60% of TI errors with a T-S similarity degree of 0. Given two words with CVC structure, the probability of no similarity between these two words is 0.52. Given two words with CV structure, the probability of no similarity between these two words is 0.62. Hence, an expected chance probability that two words have a T-S similarity degree of 0 is around 50% to 60%. The proportion of both groups of tone errors with a T-S similarity degree of 0 happens to be within this range. It indicates that the proportion of tone errors with a T-S similarity degree more than 0 is merely a proportion of chance but the proportion of segmental errors with a T-S similarity degree more than 0 is higher than expected by chance. Consequently, the different distribution between segmental errors and tone errors indicates that the context factor of phonological similarity is indeed a factor facilitating the occurrence of segmental errors but it is not a factor facilitating the occurrence of tone errors.

7. Analysis of Tone Errors With the Tone Sandhi Approach

In the previous section, we tentatively treat TI errors as context errors to make a comparison between tone errors and segmental errors. The results show that TI errors behave similarly to TIII errors. It implies that it is proper to classify all TI errors as context errors like TIII errors. However, as mentioned previously, TI errors can also be analyzed as tone sandhi errors properly. In this section we treat TI errors as tone sandhi errors alternatively like Type TII 'tone sandhi errors' (hereafter TII errors) and investigate which model related to the tone sandhi mechanism can account for those speech errors properly.

TI and TII errors in our study can be further divided into two kinds of errors, i.e. citation-tone errors and sandhi-tone errors, according to the form of the target. A citation-tone error is an error in which the target is a citation tone while the error is the sandhi tone of the target, like (8). In (8), the error tone [55] is the sandhi tone of the target tone [53]. A sandhi-tone error is the opposite. The target is a sandhi tone which is substituted by its citation tone, like (9). In (9), the error tone [32] is the citation tone of the target tone [53]. The frequency of both kinds of errors is given in Table 7.

(8) citation-tone error

tak1-e33	ka33	hue33-ɕioŋ55	[//]	hue33-ɕioŋ53	khi11-lai11, …
everyone	with	recall		recall	raise

'Everyone recalled (this experience) …'

(9) sandhi-tone error

ke53-tat1	{tɕhit5	pa32}	[//] tɕhit5	pa53	ban33	ne33	bi55-kim55
value	seven	hundred	seven	hundred	ten-thousand	DE	US dollar

'(The whole life of a person is) valued at seven million US dollars.'

Table 7 Results of tone sandhi errors

Errors / Tokens	Citation-tone error	Sandhi-tone error	Total
TI errors	24 (46%)	28 (54%)	52
TII errors	19 (59%)	13 (41%)	31
Total	43 (51%)	41 (49%)	84

Table 7 shows that citation-tone errors and sandhi-tone errors are roughly the same in number. Both are around half of the errors. Nevertheless, there is some difference between TI and TII errors with regard to the proportion of errors. In TI errors, sandhi-tone errors outnumber citation-tone errors while in TIII errors, citation-tone errors exceed sandhi-tone errors. We further discuss the mechanism of the tone sandhi phenomenon to see how these errors are resulted.

As mentioned previously, there are mainly two models in the literature accounting for the tone sandhi phenomenon. One is the rule-application model and the other is the allomorph model. According to the former, only the sandhi tone can be derived from the citation tone, but not vice versa. A theoretical implication of this model is that since citation tones are underlying tones, there should be few citation tone errors and there should be much more sandhi tone errors than citation tone errorrs. As to the allomorph model, both citation tone and sandhi tone are stored in the mental lexicon. The appearance of the surface tone is a process of selection or analogy according to the syntactic position of the given word in the utterance. Consequently, errors occurring on the selection might result in wrong selection of citation form for sandhi tone or vice versa. Hence, the allomorph model predicts that errors on citation tone or sandhi tone are both possible. The tokens of citation-tone errors and sandhi-tone errors are about the same. Accordingly, it seems to support for the allomorph model

8. Conclusion

The comparison between phonological tone errors and segmental errors show similarities as well as differences. On the one hand, both kinds of errors show similar distribution patterns with regard to the context factor of distance between the error and

the source words. It indicates that the E-S distance is a factor constraining the occurrence of errors. On the other hand, phonological tone errors and segmental errors behave differently with regard to the context factors of directionality and phonological similarities between the target and the source words.

Next, regarding the factor of language-specific tone phenomenon in the occurrence of tone errors, our study show that it not only plays a role but probably is also a more important role than context factors in accounting for Taiwanese tone errors. As to the third question concerning the mechanism of Taiwanese tone sandhi phenomenon, our data seems to provide supporting argument for the allomorph model. Based on this model, tone sandhi errors should be treated as lexical errors instead of phonological errors. If we treat tone sandhi errors as lexical errors, then in Taiwanese most tone errors are resulted from lexical errors rather than context-conditioned phonological errors.

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