



An Investigation of Vowel Epenthesis in Chinese Learners' Production of German Consonants

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Abstract

The present study investigates the influence of phonetic factors on the frequency of vowel epenthesis in the German speech of Chinese learners. The subjects were intermediate learners of German who entered Germany within five months of their study. Descriptive statistics were performed on the data collected from reading tasks, and phonetic analysis was provided to explain the phenomenon of epenthesis. In the main experiment, eighteen Chinese students were recruited to read 50 phonetically rich sentences with various sentence modes after one month residence in Germany. Results indicate that these learners employed the epenthesis strategy more or less in producing consonant codas and consonant onset clusters in German. An investigation in the frequency of epenthesis in relation to various factors demonstrates that consonant cluster length, L1 transfer, markedness, sonority, and articulatory timing influence the occurrences of epenthesis simultaneously. An additional experiment was conducted after a time span of three months, ten of these subjects were requested to read the same text, the result shows that the amount of epenthesis decreases with the increase of the length of residence and German language learning experience. These findings might shed some light on the acquisition process of consonant codas in foreign languages.

Index Terms: vowel epenthesis, L1 Chinese, L2 German

1. Introduction

The phonotactic differences between German and Chinese will affect the German consonant cluster acquisition by Chinese learners. The syllable structure of German is very complicated, which can be represented by (CCC)V(CCCC) [10]. German can allow 3 consonants in the onset and up to 4 consonants in the coda in one syllable. While the syllable structure of standard Chinese is very simple, it is mainly formed by one vowel (nucleus) with one onset consonant (C)V. Chinese does not allow consonant codas except for *-n* and *-ng*, and German initial consonant clusters are phonotactically prohibited in Chinese language. Second language learners usually employ three types of strategies to repair the illegal clusters in both onset and coda positions: epenthesis, deletion and substitution. Previous studies suggested that epenthesis and feature change are the common modification strategies for Chinese ESL learners [14], [9]. Some experts further claimed that schwa insertion is usually preferred by Chinese speakers in acquiring the English language [4]. Similar results were also found in learning German by Chinese learners [5]. Moreover, epenthesis can alter the rhythm of the German speech, an additional vowel inserted into consonant clusters can increase the percentage of vowel interval %V and decrease the standard deviation of consonant interval ΔC ,

which will change the rhythm of a stress-timed language to the direction of syllable-timed language [6]. On the other hand, an inserted schwa in word-final position can build the plural form of a noun or create the past tense of a verb in the German language. Thus epenthesis by Chinese learners will not only modify the rhythm of the German speech, but also change the meaning of what they want to express. This study will be focused on the epenthesis and try to demonstrate when and where it frequently occurs and whether it could be improved with the progress of their German language learning.

Previous studies mainly investigated Chinese ESL learners' acquisition of English consonant clusters [14], [9]. Weinberger [14] found that the longer the codas, the more frequently they were modified. Hansen [9] claimed that Mandarin learners employed different strategies based on the length of the coda, with feature change favoured for single codas, epenthesis for two-member codas, and absence for three-member codas. They have provided important information about the simplification of clusters in relation to cluster length, however, little study has been devoted to examine whether and how the linguistic environments affect the epenthesis. This study will conduct a preliminary investigation of vowel epenthesis in German speech by Chinese learners, and try to determine whether the phonetic environment of different syllable-final consonants and syllable-initial phones have influence on the occurrences of epenthesis. Statistics from our data will be discussed in terms of native language transfer, markedness, sonority, and gestural mistiming.

2. Method

The current study aims to address the following questions:

1. Does the strategy of epenthesis vary with consonant cluster length?
2. Are there any influences of the linguistic environment on the occurrence of epenthesis?
3. Which linguistic constraints affect the occurrence of epenthesis?
4. How does the strategy of epenthesis change across time?

The first collection of speech data from 18 Chinese subjects were carried out to answer the first three questions, and the second data collection was only employed for the last question.

2.1. Subjects

For the first data collection, we recruited 18 native Chinese speakers, including 10 men and 8 women, who come from different parts of China, but all of them speak standard Chinese. At the time of first recording, the subjects had been living in

Germany for one month, and all were just enrolled in the German language course for DSH exam (the German language university entrance exam for foreign students). Their ages ranged from 22 to 28. All of them had learned German for 1 to 1.5 years, and the length of formal German instructions had been around 1,200 hours. These participants could be classified as low intermediate level, they formed a homogeneous group in terms of age, L1 background, motivation, proficiency of the German language, and the length of residence in Germany. 10 speakers from them, including 5 females and 5 males, participated in the second data collection three months later. 6 German native speakers participated in the experiment as references, 1 was male and 5 were female speakers. They were between 22-30 years old and were ordinary German native speakers.

2.2. Speech data collection

In order to have certain control of the speech data, reading tasks were used for analysis. In both data collections, the subjects were instructed to read 50 phonetically and prosodically rich sentences in German. The text contains altogether 614 syllables, among which the amounts of different syllable codas of one-, two-, and three-member are 11, 16 and 5 respectively, the amounts of different syllable onsets of two- and three-member are 15 and 3 respectively. All recordings were carried out in the recording room at TU Dresden. Before the recording, the subjects were given as much time as they needed to read the text to become familiarized with it. Then each subject was individually recorded with 16 bit and 44.1k Hz by a German phonetics expert, who controlled the quality of their production.

2.3. Analysis

The sentences were first automatically labeled by a trained aligner, and then manually corrected by the first author in Praat [2]. Great attention was paid to the presence of epenthetic vowel. The criteria were both audio and visual, a clearly visible formant structure in the spectrogram of a perceptible additional schwa justified the presence of epenthesis.

3. Results

The results of the research are presented from general classification to detailed categorization.

3.1. General occurrences

The insertion of schwa-like vowel can occur in 2- and 3-member consonant onsets, but after 1-, 2- and 3-member consonant codas. The occurrences of epenthesis in the consonant codas of 18 Chinese speakers are presented in Figure 1.

It is obvious that speakers have quite different performances in producing epenthesis after syllable codas. The overall occurrences range from 1 to 87, with the average of 35.72. From this figure we can observe that the absolute occurrences after 3-member codas are much smaller than those after 1- or 2-member codas. If we compare the total *sum of codas* with the *proportion of epenthesis* in Table 1, we find that 3-member codas have a higher proportion to induce epenthesis.

A two sample t-test reveals that significant difference exists only between proportions of epenthesis after 1- and 2-member syllable codas with $p < 0.05$ ($t=2.162$, $df=5956$). Though a higher proportion of epenthesis occurs in 3-member codas, no significant differences can be determined due to its small amounts in the data.

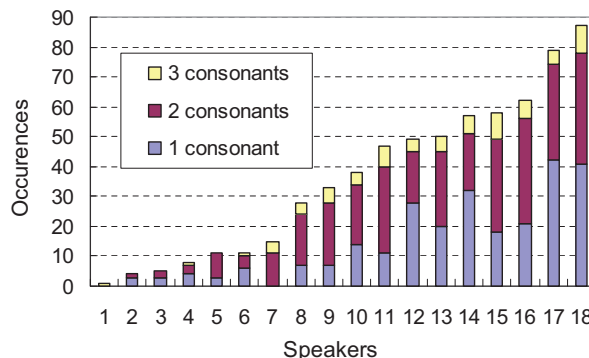


Figure 1: Occurrences of epenthesis after syllable codas.

Table 1: Proportion of epenthesis after syllable codas with 1-3 members, represented by 1-C, 2-Cs and 3-Cs respectively.

| | 1-C | 2-Cs | 3-Cs |
|--------------------------|------|-------|-------|
| sum of codas | 4824 | 1134 | 180 |
| proportion of epenthesis | 5.4% | 27.5% | 39.4% |

There are fewer epenthesis of these speakers in the consonant onsets than codas, no significant difference can be found due to small samples. However more epenthesis in 2-member than in 3-member clusters can be observed in Figure 2.

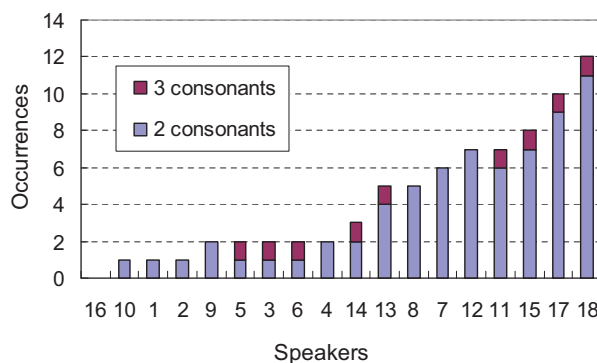


Figure 2: Occurrences of epenthesis in syllable onset clusters.

Similarly, a comparison of the total *sum of codas* of all speakers with the *proportion of epenthesis* in syllable onsets in Table 2 shows that 3-member codas have a higher proportion to induce epenthesis than 2-member clusters.

It is obvious that the sum of clusters and proportion of epenthesis in onsets are much smaller than those in the codas. Our attention will then be focused mainly on syllable codas.

3.2. Syllable-final consonants

There are 20 consonants in German, because of word final devoicing, and phonological constraints, there are only 12 consonants which can normally appear at the final position of a syllable, they are all included in our database. The frequency of epenthesis after these consonants at the syllable final position are demonstrated in Figure 3.

It is obvious that /t/ favours epenthesis by far. However in natural speech /t/ also appears as syllable coda most frequently.

Table 2: Proportion of epenthesis in syllable onsets with 2-3 members, represented by 2-Cs and 3-Cs respectively.

| | 2-Cs | 3-C2 |
|--------------------------|-------|-------|
| sum of codas | 540 | 54 |
| proportion of epenthesis | 12.4% | 16.7% |

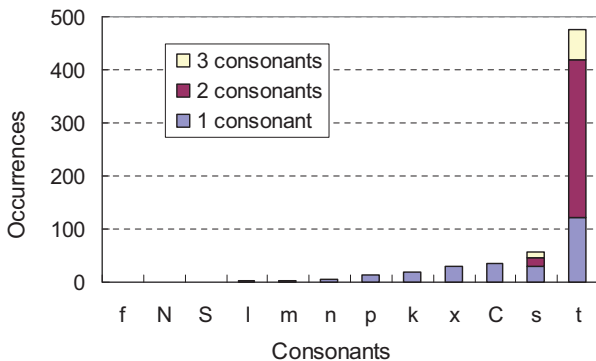


Figure 3: Epenthesis occurrences after various consonants.

We examined the *sum* of consonant codas and the *proportion* (*prop.*) of epenthesis occurred after the correspondent consonant in the speech data, which is demonstrated in Table 3.

Table 3: Proportion of epenthesis after various consonants.

| C | 1-C | | 2-Cs | | 3-Cs | |
|---|--------|------|--------|-----|--------|-----|
| | prop. | sum | prop. | sum | prop. | sum |
| f | 0% | 72 | - | 0 | - | 0 |
| S | - | 0 | 5.56% | 18 | 0 | - |
| n | 0.27% | 1854 | - | 0 | - | 0 |
| l | 1.04% | 288 | - | 0 | - | 0 |
| N | 1.39% | 72 | - | 0 | - | 0 |
| n | 1.85% | 216 | - | 0 | - | 0 |
| s | 3.47% | 864 | 6.94% | 216 | 16.67% | 72 |
| C | 6.09% | 558 | - | 0 | - | 0 |
| p | 12.04% | 108 | - | 0 | - | 0 |
| x | 13.89% | 216 | - | 0 | - | 0 |
| k | 16.67% | 108 | - | 0 | - | 0 |
| t | 26.07% | 468 | 32.89% | 900 | 54.63% | 108 |

We can observe that plosives /t/, /k/ and /p/ as well as the velar fricative /x/ induce more epenthesis than other consonant codas.

3.3. Syllable-initial phones

It is argued that epenthesis is influenced by both the previous syllable-coda consonant and the following phone at the initial position of the next syllable. Since /t/ is the consonant, after which most epenthesis occur, a detailed examination of the *sum* of next phone and the *proportion* (*prop.*) of epenthesis in front of the correspondent syllable-initial phone in the speech data is demonstrated in Table 4 (# stands for pauses):

Some results can be summarized in the following:

- The same constant /t/ triggers the most epenthesis.
- Epenthesis occurs also before vowel-initial syllables.
- Least epenthesis occurs before pauses.

Table 4: Proportion of epenthesis before various syllable-initial phones.

| phone | sum | prop. | phone | sum | prop. |
|-------|-----|--------|-------|-----|--------|
| # | 252 | 1.98% | aU | 18 | 38.89% |
| k | 18 | 11.11% | E | 54 | 38.89% |
| y: | 36 | 13.89% | d | 342 | 38.89% |
| j | 18 | 22.22% | m | 126 | 40.48% |
| S | 54 | 22.22% | z | 54 | 42.59% |
| f | 72 | 22.22% | v | 18 | 44.44% |
| h | 90 | 23.33% | g | 36 | 44.44% |
| b | 36 | 36.11% | aI | 36 | 52.78% |
| l | 54 | 37.04% | n | 36 | 58.33% |
| a | 90 | 37.78% | r | 18 | 61.11% |
| | | | t | 36 | 69.44% |

With another investigation of the following phones which follow epenthesis after /s/, we find that /S/ is the one which induces the most epenthesis with a percentage of 22.22%. Since there is no consecutive /s/s in our text data, /S/ is the consonant which is similar to /s/ with regard to place and manner of articulation.

3.4. Vowel-initial glottalization

Glottal stops are reported to appear frequently at the left edge of a vowel-initial syllable ([11], [13]). All the 6 German native speakers show no epenthesis, except that glottalized part before vowel initial sometimes resembles a reduced schwa acoustically. The glottalization /ʔ/ in Figure 4 is similar to a reduced schwa, but is quite different from the lexical schwa insertion /@/ of Chinese students before the glotal stop /ʔ/ in Figure 5.

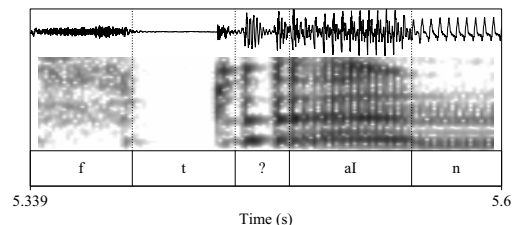


Figure 4: Glottalization of vowel-initial by a German speaker.

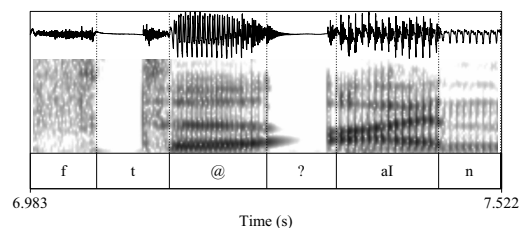


Figure 5: Epenthesis before glottalization by a Chinese speaker.

3.5. Longitudinal comparison

It is found that after three months' intensive German courses and residences, all Chinese learners reduced their epenthesis.

10 speakers from 18 subjects were required to take part in the second data collection, the results are illustrated in Figure 6.

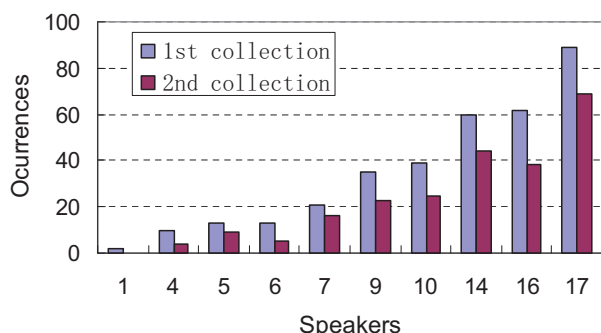


Figure 6: Comparison of epenthesis occurrences after a time span of 3 months.

4. Discussion

The merit of the current study with naturally occurring data is that it can help us to understand many facts in the acquisition of German by Chinese students, for example, why there are so many epenthesis occurring after /t/. The disadvantage of using natural data is that we have to be very cautious in drawing conclusions, since we had no control of various factors. Based on the descriptive statistics, we try to provide some explanations to the above-mentioned questions:

1. Epenthesis favors 2- and 3-member codas than 1-member. It should be investigated with larger databases to determine the significance of the proportion difference between 2- and 3-members.
2. Both syllable-final consonant before the epenthesis and syllable-initial phone after epenthesis affect the frequency of epenthesis.
3. L1 transfer, markedness, sonority and gestural mistiming can have influence on the occurrence of epenthesis simultaneously.
4. Epenthesis could be reduced with the progress of target language acquisition.

Some further discussions will be carried out in the aspects of linguistic constraints.

- L1 transfer can be an important argument for learners to insert vowels to repair illegal codas or clusters in L2. Another observation is that some speakers inserted /u/ after /p/, and /i/ after /s/. Because the consonants /p/ and /s/ are pronounced as /pu/ and /si/ respectively in Chinese. Speakers inserted vowels to preserve the phonetic characteristics of consonants in L1.
- It is claimed that learners acquire unmarked segments before producing marked ones. Since longer consonant clusters are more marked, higher proportions of epenthesis were found in longer clusters, as it is demonstrated by the statistics.
- It is found that consonant codas with least sonority, such as stops /t/, /p/ and /k/, and fricatives /x/, /C/ and /s/, triggered epenthesis more frequently than nasals in our

data. /f/ was an exception, which deserves further investigation with controlled environments. However we did not test whether “clusters whose members are closer in sonority are more marked than clusters whose members are farther apart on the sonority hierarchy” [1]. This rule is usually applied to consonant clusters, which was not investigated in this study due to unequal appearances of various combination of 2-member clusters.

- Many cases of epenthesis may not be lexical schwas, but rather “mistiming” articulatory gestures, as it is claimed by articulatory phonology [7]. It is further proved that this kind of schwa is acoustically different from lexical schwa [4]. There was some evidence for this argument in our data: 1) Least proportion of epenthesis appeared before pauses, because no articulatory coordination was necessary; 2) Epenthesis frequently occurred after syllable-final /t/ when the next phone is also /t/ at the syllable initial. Since two identical consonants must be produced in sequence usually result in /C@C/, this fact is formally expressed as an effect of a gestural version of the Obligatory Contour Principle by McCarthy [12]; 3) Epenthesis frequently occurred before glottalization. In the glottalized part, the glottal stops could be prolonged, and schwa was resulted. Previous studies in German vowel-initial glottalization reported that the preceding plosive context triggers the highest proportion of glottal stops [11], and low vowels favour glottalization [13]. This can explain why epenthesis occurred frequently after /t/ and before /aI/.

Some findings in this study can be different from that of Chinese ESL speakers reported in previous research. For example, it is reported that over 50% of the instances of epenthesis after word-final consonants occurred before a pause, 40 percent before word-initial consonants, and less than 5 percent occurred before word-initial vowels [3]. However our example of /t/ does not support this claim. There are many reasons: perhaps glottalization of word-initial vowel in German could trigger “mistiming” schwa; we regarded the long closure part in the word-initial stop as part of the stop rather than a pause; and the proficiency of speakers could also be different.

5. Conclusions

With respect to the prevalence of insertion used by Chinese speakers, both lexical schwa and schwa due to “mistiming” existed in the speech data. With the progress of L2 acquisition, lexical insertions can be gradually replaced by “mistiming” insertions, and a final elimination of epenthesis is still attainable. Many segmental and prosodic factors operate simultaneously on the occurrences of epenthesis, and it is also language- and speaker-dependent. As remarked by Hall [8] vowel epenthesis processes are greatly heterogeneous. And the findings in this study can serve as a basis for further controlled experiments with well designed material.

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7. References

- [1] Broselow, E., Finer, D. “Parameter setting in second language phonology and syntax”, *Second Language Research*, 7(1):35-59, 1991.
- [2] Paul Boersma, P. and Weenink, D. “Praat: doing phonetics by computer [Computer program]”, <http://www.praat.org/>, 2013.
- [3] Carlisle, R. S., “Markedness and environment as internal constraints on the variability of interlanguage phonology”, in M. Yavas [Ed.], *First and Second Language Phonology*. San Diego, CA: Singular Publishing Group, Inc. 1994.
- [4] Davidson, L., “Phonology, phonetics, or frequency: Influences on the production of non-native sequences”, *Journal of Phonetics*, 34:104-137, 2006.
- [5] Ding, H., Mixdorff, H. and Jokisch, O., “Pronunciation of German Syllable Codas of Mandarin Chinese Speakers”, in H. Mixdorff [Ed.], *Electronic Speech Signal Processing 2010*, 281-287, TUDpress, 2010.
- [6] Ding, H., Jäckel, R. and Hoffmann, R., “A Preliminary Investigation of German Rhythm by Chinese Learners”, in P. Wagner [Ed.], *Electronic Speech Signal Processing 2013*, TUDpress, 2013 (in press).
- [7] Gafos, A., “A grammar of gestural coordination”, *Natural Language and Linguistic Theory*, 20(2): 269–337, 2002.
- [8] Hall, N., “Vowel Epenthesis”, in van Oostendorp, M. et al. [Eds], *The blackwell Companion to Phonology*, Wiley-Blackwell, 1576–1596, 2011.
- [9] Hansen, J. G., “Linguistic constraints on the acquisition of English syllable codas by native speakers of Mandarin Chinese”, *Applied Linguistics*, 22:338–365, 2001.
- [10] Kohler, K. J., “Einführung in die Phonetik des Deutschen”, Schmidt, Berlin, 1977.
- [11] Kohler, K. J., “Glottal stops and glottalization in German”, *Phonetica*, 51:38–51, 1994.
- [12] McCarthy, J. J., “OCP Effects: Gemination and Antigemination”, *Linguistic Inquiry* 17: 207–263, 1986.
- [13] Pompino-Marschall, B. and Zygis, M., “Glottal marking of vowel-initial words in German”, in M. Weirich and S. Jannedy, [Eds], *Papers from the Linguistics Laboratory, ZASPIL 52:1–17*, 2010.
- [14] Weinberger, S. H., “The influence of linguistic context on syllable simplification”, in G. Ioup and S. H. Weinberger [Eds], *Interlanguage Phonology: The Acquisition of a Second Language Sound System*, Cambridge, MA: Newbury House, 1987.