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

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1. Introduction

The present study investigates the influence of phonetic factors on the frequency of vowel epenthes 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 epenthes. 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 epenthes strategy more or less in producing consonant codas and consonant onset clusters in German. An investigation in the frequency of epenthes in relation to various factors demonstrates that consonant cluster length, L1 transfer, markedness, sonority, and articulatory timing influence the occurrences of epenthes 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 epenthes 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 epenthes, L1 Chinese, L2 German

2. Method

The current study aims to address the following questions:

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

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

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.

<table>
<thead>
<tr>
<th></th>
<th>2-Cs</th>
<th>3-Cs</th>
</tr>
</thead>
<tbody>
<tr>
<td>sum of codas</td>
<td>540</td>
<td>54</td>
</tr>
<tr>
<td>proportion of epenthesis</td>
<td>12.4%</td>
<td>16.7%</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>C</th>
<th>1-C</th>
<th>sum</th>
<th>2-Cs</th>
<th>prop.</th>
<th>sum</th>
<th>3-Cs</th>
<th>prop.</th>
<th>sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td>0%</td>
<td>72</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>S</td>
<td>-</td>
<td>0</td>
<td>5.56%</td>
<td>18</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>n</td>
<td>0.27%</td>
<td>1854</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>l</td>
<td>1.04%</td>
<td>288</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>N</td>
<td>1.39%</td>
<td>72</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>n</td>
<td>1.85%</td>
<td>216</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>s</td>
<td>3.47%</td>
<td>864</td>
<td>6.94%</td>
<td>216</td>
<td>16.67%</td>
<td>72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>6.09%</td>
<td>558</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>P</td>
<td>12.04%</td>
<td>108</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>x</td>
<td>13.89%</td>
<td>216</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>t</td>
<td>16.67%</td>
<td>108</td>
<td>-</td>
<td>0</td>
<td>54.63%</td>
<td>108</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We can observe that plosives /t/, /k/ and /p/ as well as the velar fricative /x/ induce more epentheses 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 epentheses 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):

<table>
<thead>
<tr>
<th>phone</th>
<th>sum</th>
<th>prop.</th>
<th>phone</th>
<th>sum</th>
<th>prop.</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
<td>252</td>
<td>1.98%</td>
<td>aU</td>
<td>18</td>
<td>38.89%</td>
</tr>
<tr>
<td>k</td>
<td>18</td>
<td>11.11%</td>
<td>E</td>
<td>54</td>
<td>38.89%</td>
</tr>
<tr>
<td>y</td>
<td>36</td>
<td>13.89%</td>
<td>d</td>
<td>342</td>
<td>38.89%</td>
</tr>
<tr>
<td>j</td>
<td>18</td>
<td>22.22%</td>
<td>m</td>
<td>126</td>
<td>40.48%</td>
</tr>
<tr>
<td>S</td>
<td>54</td>
<td>22.22%</td>
<td>z</td>
<td>54</td>
<td>42.59%</td>
</tr>
<tr>
<td>f</td>
<td>72</td>
<td>22.22%</td>
<td>v</td>
<td>18</td>
<td>44.44%</td>
</tr>
<tr>
<td>h</td>
<td>90</td>
<td>23.33%</td>
<td>g</td>
<td>36</td>
<td>44.44%</td>
</tr>
<tr>
<td>b</td>
<td>36</td>
<td>36.11%</td>
<td>al</td>
<td>36</td>
<td>52.78%</td>
</tr>
<tr>
<td>l</td>
<td>54</td>
<td>37.04%</td>
<td>n</td>
<td>36</td>
<td>58.33%</td>
</tr>
<tr>
<td>a</td>
<td>90</td>
<td>37.78%</td>
<td>r</td>
<td>18</td>
<td>61.11%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>t</td>
<td>36</td>
<td>69.44%</td>
</tr>
</tbody>
</table>

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 /?/ in Figure 4 is similar to a reduced schwa, but is quite different from the lexical schwa insertion /@/ of Chinese students before the glottal stop /?/ in Figure 5.

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

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

![Comparison of epenthesis occurrences after a time span of 3 months.](image)

**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 epentheses 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 /ʃ/, /ʃ/ and /s/, triggered epenthesis more frequently than nasals in our data. /ʃ/ 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 /u/ and before /al/.

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 /u/ 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.

### 6. Acknowledgements

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7. References


