Chapter eight

Intelligibility of consonant clusters

8.1 Introduction

In this chapter I will present the results for intelligibility of intervocalic consonant clusters for three groups of listeners. The results are from the same groups of listeners as in the previous chapters. Since simplex consonants and consonant clusters are all composed of the same phonetic substance, i.e. consonants, we might expect few or no significant differences between the results of the previous and the present chapters. However, consonant clusters are conspicuously absent in Mandarin Chinese. We know from work on other languages (see Chapter two) that clusters constitute a source of difficulty – and such problems may also be found for Chinese learners of English. The format of our experiment does not allow us to test such escape strategies as vowel insertion to break up awkward clusters (as happens in the English of Japanese or Indonesian learners). Nor can the alternative, deleting one of the consonants from the input cluster, be checked in our data, unless a three-member cluster were simplified to a two-member cluster. We must bear in mind that the forced-choice paradigm used in our experiment may have led to an overestimation of the quality of the pronunciation (and identification) of consonant clusters.

8.2 Results

8.2.1 Overall results

The overall results for cluster intelligibility are presented in Figure 8.1, broken down by nationality of the listeners and broken down further by nationality of the speakers. As in Chapters six and seven, the data were submitted to an Analysis of Variance (ANOVA) run on the mean percent correct scores for each listener with nationality (or: language background) of speaker and nationality of listener as fixed factors.

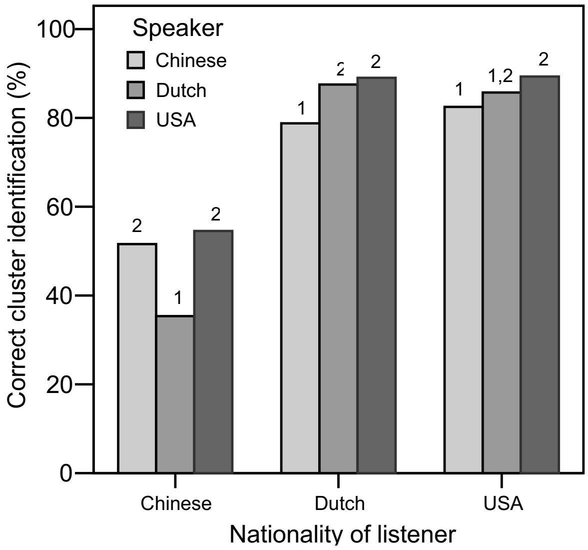

Figure 8.1. Percent correctly identified consonant clusters for Chinese, Dutch and American listeners broken down by accent of speakers. Numbers above the bars indicate the subgroup membership as determined by the Scheffé procedure. Numerical values of means, N, SD and Se are included in Appendix A8.1.

Across the speaker groups, the Chinese listeners have the lowest consonant cluster identification scores (53 to 56% correct, mean = 48%). Dutch listeners perform very closely to American listeners (79 to 89% correct, mean = 85%), and the American listeners are the best (82 to 89% correct, mean = 86%). The main effect of listener is highly significant, $F(2, 315) = 371.0$ ($p < .001$). Scheffé post hoc tests reveal that the Chinese listeners differ from Dutch and American listeners, who do not differ from each other.

The effect of speaker nationality is also significant but much less so than the effect of listener, $F(2, 315) = 15.9$ ($p < .001$). In fact, the listener effect in the cluster data is more than 20 times stronger than the speaker effect. The Dutch (mean = 70%) and the Chinese (mean = 71%) speakers do not differ from each other, but both are poorer than the American speakers (mean = 78%).

Figure 8.1 shows overall correct consonant cluster identification. It does not allow us to identify individual clusters that represent special difficulties. Therefore, we ask, firstly, which are the problematic clusters for each group of listeners? This question will be taken up in the following section (§ 8.2.2). Secondly, if a sound is massively misidentified, then what is it heard as instead? This question will be dealt with later when we examine the confusion structure in the cluster data (§ 8.2.3).

8.2.2 Correct cluster identification

In order to get an overview of which clusters are more difficult than others, for each combination of speaker and listener nationality, we present the percentages of clusters correctly identified by Chinese, Dutch and American listeners in separate panels in Figure 8.2. In each panel the results have been broken down by nationality of the speakers. Per panel, the 21 consonant clusters have been ordered in descending order of correct identification, when the speakers are American. The intelligibility for specific consonant clusters may differ widely between speaker nationalities. Table 8.1 lists Pearson's r for percent correct cluster identification in the three pairs of speaker nationalities for each of the three listener groups. The r-values are low and do not reach statistical significance, except those between Dutch and American speakers when the listeners are not Chinese; here the coefficients are between .5 and .6, which is significant at the $p < .05$ and $p < .01$ levels, respectively. Apparently, the consonant clusters spoken by native English and non-native Dutch speakers are to some extent (relatively) equally difficult. This would seem to make sense, since the English and Dutch sound systems have a large inventory of (often the same) consonant clusters, whilst Chinese has no consonant clusters at all.[1]

[1] Chinese has consonant clusters on the surface. These are combinations of some onset consonant followed by a glide /j/ or /w/, which in the phonology of Chinese are not counted as part of the onset but are parsed with the vowel. Only one such cluster was included in our test materials, viz. /sw/, which happens to be a combination that does not occur in the Chinese inventory.

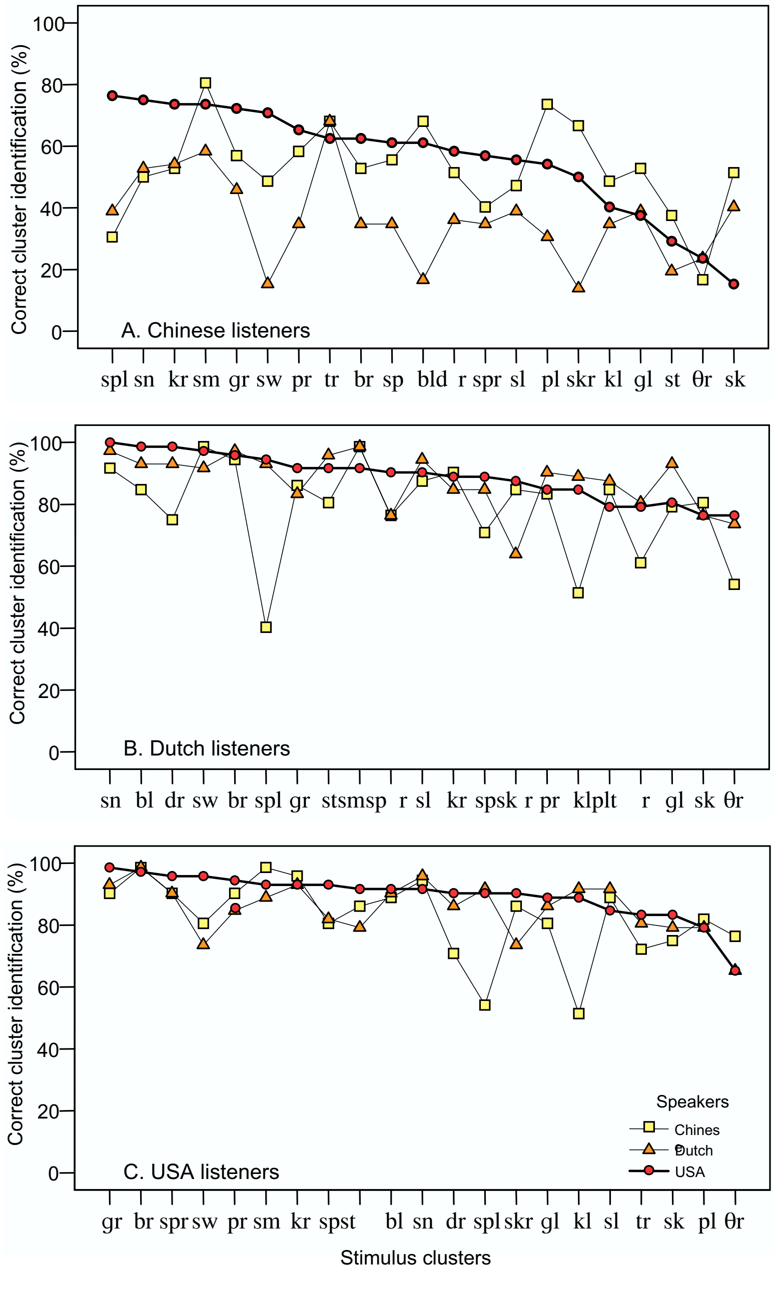

Figure 8.2. Correct identification (%) of 21 English intervocalic consonants produced by Chinese, Dutch and American speakers. Panels A, B and C present the results for Chinese, Dutch and American listeners, respectively.

Table 8.1. Pearson's correlation coefficients for identification of consonant clusters produced by Chinese, Dutch and American speakers broken down by nationality of the listeners.

Listener nationality	Speaker nationalities		
	CN ~ NL	CN ~ US	NL ~ US
CN	.268	.330	.362
NL	.255	.346	.545*
US	.217	.340	.606**

*: p < .05; **: p < .01

Figure 8.2-A shows the Chinese listeners' identification of the 21 consonant clusters of Chinese, Dutch and American speakers. The correct identification rate for American speakers runs from more than 80% (for /gl/) down to 16% (for /sk/). It is not the case that the American speakers' cluster tokens are more intelligible than the non-native tokens as has happened in the results for the simplex consonants. Six Chinese-accented consonant clusters are clearly identified better by Chinese listeners; these are /pl, skr, gl, kl, st, sk/. Dutch-accented clusters are extremely difficult for Chinese listeners. Almost all the clusters are identified more poorly than either Chinese-accented clusters or than the native American tokens. Especially the clusters /sw, bl, skr/ are poorly (< 20% correct) identified.

Figure 8.2-B shows the Dutch listeners' identification of the 21 consonant clusters of Chinese, Dutch and American speakers. The correctness of American consonant tokens covers a range from 99% to 80%. In this figure we can see that the American speakers' tokens almost invariably get the highest identification scores, with no significant exceptions. When Dutch listeners listen to their fellow speakers, there are just few clusters, /skr, spr/, that are identified clearly more poorly than the American counterparts. Chinese-accented consonant clusters are obviously the most difficult tokens for Dutch listeners as also happened in the case of the simplex consonants (Chapter seven). Chinese-accented /spl, kl, tr, θr/ are especially difficult for the Dutch listeners (between 40 and 60% error).

Figure 8.2-C shows American listeners' identification of the 21 consonant clusters of Chinese, Dutch and American speakers. The percentage is presented in the order of correctness from high (97%) to low (70%) of every consonant produced and identified by American native speakers. American listeners have the highest identification score for /br/ produced by their own speakers and the lowest identification for /θr/ (67%). This indicates that native American listeners have problems with their own speakers for certain consonant clusters. Nevertheless, there is substantial native language benefit, as the scores for other speaker nationalities are poorer overall. Dutch-accented clusters and Chinese-accented clusters are both poorly identified by American listeners but the figure reveals that the problematic consonant clusters may differ between the two non-native varieties of English. In responding to Dutch accented clusters, American listeners have clear difficulties in listening to /tr, θr, sw/; difficult Chinese-accented clusters are /kl, gl, st, sk, spl/.

We will now examine the confusion structures among the sets of consonant clusters, for each combination of listener and speaker nationality, in an attempt to understand why certain clusters present specific problems.

8.2.3 Confusion structure in consonant clusters

The clusters have been arranged in a matrix-like structure such that place of articulation appears along the vertical axis, with labials at the top, alveolars in the middle and velars at the bottom of the matrix. Each category along the vertical dimension has a top row and a bottom row. The top rows exclusively list two-member clusters; three-member clusters are on the bottom rows (midway between voiced and voiceless). The horizontal axis of the matrix is composite. The first two columns comprise /sC/ clusters, where C is a plosive in the first column and a sonorant in the second column. The third and fourth columns list obstruent + /r/ clusters, while the fifth and sixth columns list obstruent + /l/ clusters. Within each pair of columns, voiceless obstruents appear on the left (in odd-numbered columns) and their voiced counterparts to the right in even-numbered columns. Voicing is not contrastive in three-member clusters; hence these have been listed in between the odd and even-numbered columns, when applicable. As before, in order to avoid visual clutter, only confusion pairs have been indicated with arrows when the specific confusion occurred in 20% or more of the responses to the stimulus.

8.2.3.1 Cluster confusion for Chinese listeners

Figure 8.3A-C shows the cluster confusion structure for Chinese listeners responding to Chinese, Dutch and American speakers of English, respectively. The graphs show that the number of strongly confused cluster types is small, much smaller than was the case for either vowels or simplex consonants.

In Figure 8.3 A, Chinese listeners confused Chinese-accented /st/ with /sp/ (31%), /spl/ with /spr/ (31%) and /sl/ with /spl/ (21%). When listening to Dutch-accented clusters (figure 8.3B) /spl/ is identified as /spr/ (33%), /tr/ as /θr/ (23%) and /gr/ as /kr/ (25%). There are only two confusion pairs when Chinese listeners respond to American speakers /spl > spr/ (26%) and /kl > kr/ (33%).

Interestingly, the /spl > spr/ confusion pair is a problem for Chinese listener irrespective of the nationality of the speakers. This would indicate, of course, that the source of the confusion is not so much in a speaker defect but in the perception. Chinese listeners are relatively insensitive to the /r/ ~ /l/ contrast, and it does not matter very much whether the contrast is properly marked in the stimulus. It would seem, moreover, that the confusion is restricted to three-member clusters only; /l/ and /r/ were not confused as simplex consonants (Chapter seven). It is not clear why the confusion is directional from /spl/ to /spr/ only. The same directionality is observed in /kl > kr/; never do we find a confusion from /r/ to /l/.

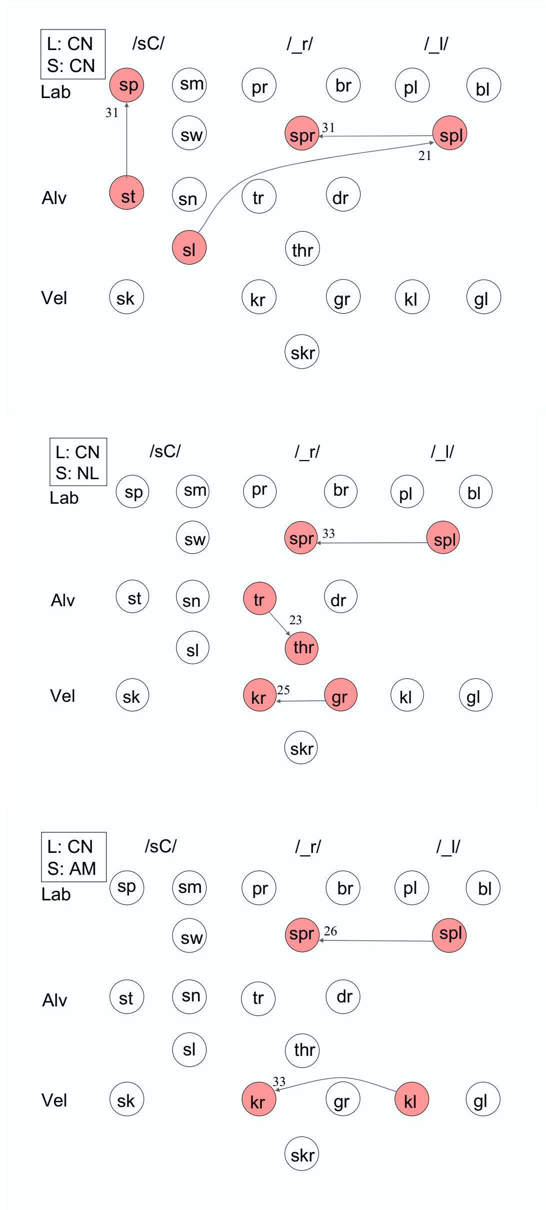

Figure 8.3A-C. Confusion graphs for Chinese listeners, exposed to Chinese (CN), Dutch (NL) and American (US) speakers (from top to bottom). Only confusions ≥ 20% are indicated by arrows. L= listeners, S = speakers.

8.2.3.2 Cluster confusions for Dutch and American listeners

Figure 8.4A-B lists the confusion pairs for consonant clusters for Dutch and American listeners, respectively, when exposed to Chinese-accented consonant clusters. When the speakers are either American or Dutch, no confusion pairs were obtained with a frequency ≥ 20%, which is why the confusion graphs involving Dutch or American speakers will not be presented (they would not show any arrows).

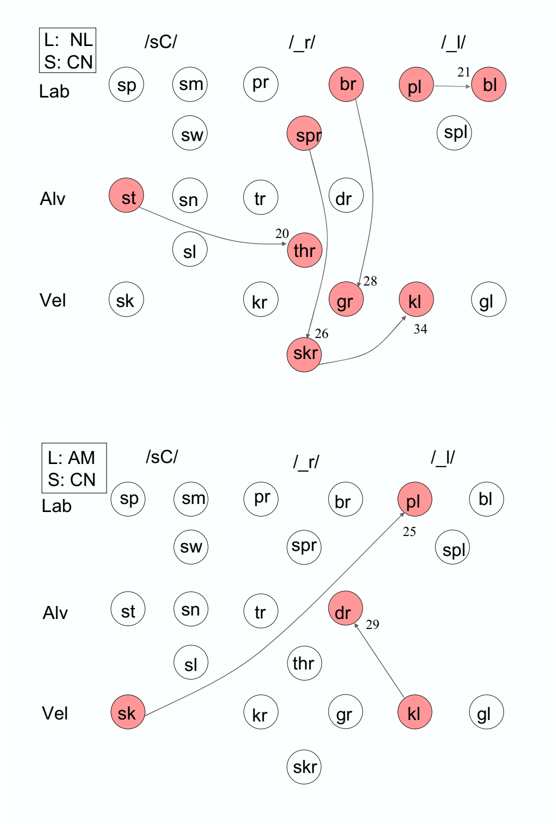

Figure 8.4A-B. Confusion graphs for Dutch (NL) and American (US) listeners, exposed to Chinese (CN) speakers. Only confusions ≥ 20% are indicated by arrows. L = listeners, S = speakers.

As could already be seen in the presentation of the percentages correct (Figure 8.2), consonant clusters are not really a problem between Dutch and American speakers and listeners – at least not when determined in a forced choice paradigm allowing cluster responses only. Apparently, the sound systems of Dutch and English are similar enough to prevent large-scale confusion in the consonant clusters.

However, when the speakers are Chinese we find five confusion pairs. With the exception of one (/pl > bl/) all these confusion pairs involve a cluster – either as source or as target – that contains a consonant or a sequence that is illegal in the sound system of Dutch: /br > *gr/, /*skr > kl/, /st > *θr/ and /spr > *skr/. Since none of these confusions are found when the listeners are American (next section), I suggest that the problem is caused by the Dutch listeners.

Only two confusion pairs remain when the listeners are American. One involves an /l > r/ confusion (/kl > dr/) but not the reverse. The other pair, /sk > pl/, is not part of a recurring pattern.

8. 3 Summary

Table 8.2 lists the number of problematic consonant clusters in the data. A problematic cluster is defined as a cluster which in any speaker-hearer combination is identified correctly in less than 75%. The numbers are broken down for the nine combinations of speaker and listener language background.

Table 8.2. Number of problematic consonant clusters broken down by nationality of speaker and of listener.

speaker	listener			
	Chinese	Dutch	USA	Total
Chinese	**20**	5	18	43
Dutch	21	**1**	0	22
USA	19	0	**1**	20
Total number	60	6	19	85

Table 8.2 shows that, overall, Dutch listeners have the least number of problematic consonant clusters in the three groups of listeners. American listeners are a good second, and Chinese listeners clearly have the most problems. The number of problematic clusters is 60 out of 85 in the Chinese listener group (75%) and 43 out of 85 in the Chinese speaker group (51%).

8.4 Conclusions and discussion

We hypothesized that English consonant clusters would be more difficult to identify, as the sound system of the L2 speaker's native language deviates more from English. The differences between the Dutch and Chinese consonant inventories are relatively small, and both languages have roughly the same number of consonants that would be reasonable substitutes for English targets, but there are no consonant clusters in Mandarin Chinese. In this respect the prediction is rather different than either in the case of the vowel systems or in the case of the consonant systems. The results show that Chinese-accented consonant clusters are relatively well identified by all groups of listeners, and certainly better than the vowels (Chapter six) and simplex consonants (Chapter seven). Dutch-accented consonant clusters are very well identified by American listeners and by the Dutch listeners themselves, but not by Chinese listeners. Dutch-accented consonant clusters are the most difficult for Chinese listeners. The difference in intelligibility between Chinese and Dutch-accented consonants is relatively large.

In spite of the intelligibility of some Chinese-accented consonant clusters, we observed that there are very few clusters that are clearly more intelligible than their native American counterparts. This is in contrast with our earlier findings for simplex consonants, where we found a range of Chinese-accented consonants which were better identified by Chinese listeners than American native tokens of the same consonants: /p, f, w, s, z, ʃ, tʃ/.