Cross-linguistic influences on the production of third language consonant clusters by L1 Cantonese–L2 English–L3 German trilinguals

Yanjiao Zhu & Peggy Mok

INTERNATIONAL JOURNAL OF MULTILINGUALISM
https://doi.org/10.1080/14790718.2023.2208866

Routledge
Taylor & Francis Group

Check for updates

Cross-linguistic influences on the production of third language consonant clusters by L1 Cantonese–L2 English–L3 German trilinguals

Yanjiao Zhu[a] and Peggy Mok[b]

[a]School of Foreign Languages, University of Electronic Science and Technology of China, Chengdu, People's Republic of China; [b]Department of Linguistics and Modern Languages, The Chinese University of Hong Kong, Hong Kong, People's Republic of China

ABSTRACT
This study examines the production of third language (L3) German consonant clusters by 26 L1 Cantonese–L2 English bilinguals, with the aim of uncovering the possible cross-linguistic influences on L3 pronunciation. Learners' production of 17 onset and 21 coda German consonant clusters were auditorily analysed with respect to accuracy and error type. Findings showed that L3 pronunciation accuracy was affected by the similarities between each individual L3 consonant cluster and its possible correspondences in L1 Cantonese and L2 English. An L3 German consonant cluster that contained more Cantonese and English consonants would be produced more accurately, whereas an L3 consonant cluster that looked similar to English but mismatched with English orthography would generate production errors (e.g. kn [kn] → kn [n]). Individual variation between different L3 consonant clusters suggests that cross-linguistic influences on the L3 can occur from both the L1 and the L2 at the feature level and can be both positive and negative. At the same time, the study also shows that L3 speech is significantly influenced by markedness and language experience factors.

ARTICLE HISTORY
Received 6 June 2022
Accepted 25 April 2023

KEYWORDS
L3 acquisition; consonant cluster; cross-linguistic influence

Introduction

For multilingual speakers, a question often asked is how their different languages interact to influence one another, which has generated various theoretical models regarding the possibilities of cross-linguistic influence (CLI) on third language (L3) acquisition. The present study approaches this problem by assessing the acquisition of L3 consonant clusters, structures which have not received much interest in previous L3 research. Consonant clusters are found in languages that have complex syllable structures, but not all languages allow complex syllable structures. Therefore, consonant clusters are difficult to learn for L2 learners whose L1 disallows complex syllable structures. For instance, Cantonese only allows simple CV or CVC structures (Yip & Matthews, 2011), hence Cantonese speakers have difficulty with consonant clusters in L2 English (Chan, 2006; Chan & Li, 2000; Setter, 2008). When it comes to L3 consonant cluster acquisition, it is more difficult to predict

CONTACT Peggy Mok peggymok@cuhk.edu.hk Department of Linguistics and Modern Languages, The Chinese University of Hong Kong, Hong Kong, People's Republic of China

learners' performance, as the L3 may experience complex CLI from both the L1 and the L2. For instance, given the fact that Cantonese L1 speakers find it hard to produce L2 English consonant clusters, would they experience the same difficulties in learning L3 consonant clusters, if they continue to learn an L3 German? Or would the L3 learners carry their L2 English consonant cluster experience onto the L3, which may facilitate the acquisition of L3 consonant clusters? In this case, consonant clusters give us a window to explore CLI in L3 phonological acquisition. For L3 German learners of L1 Cantonese and L2 English, whose L1 only allows simple structures but whose L2 has complex syllable structures, it is interesting to explore their L3 consonant cluster production in order to reveal whether and to what extent L1 and L2 play a role in L3 consonant cluster acquisition.

The influence of language background on consonant cluster acquisition

Consonant clusters have been extensively studied in L2 acquisition research, and it is widely acknowledged that L2 consonant cluster production is under the influence of learners' L1 consonant inventory and syllable structures. Broselow and Finer (1991) suggested that the L2 English C*j* and C*r* onset clusters were easier for Hindi-speaking learners, whose L1 contains these clusters, than for Japanese- or Korean-speaking learners, whose L1s do not allow these clusters. Similarly, Eckman (1981) found that in the production of L2 English final voiced obstruents, Mandarin L1 and Japanese L1 speakers were more likely to add a final schwa, whereas Cantonese L1 and Spanish L1 speakers more often devoiced the final obstruent, as Cantonese and Spanish allow final obstruents while Mandarin and Japanese do not. Hancin-Bhatt and Bhatt (1997) showed that L1 Spanish learners were more accurate than L1 Japanese learners at producing L2 English obstruent-sonorant onsets, as obstruent-sonorant onsets are allowed in Spanish but not in Japanese. In sum, previous L2 studies have shown that consonant clusters that exist in L1 will be easier to acquire than those that are nonexistent in L1, and that learners tend to replace consonant clusters according to their L1 consonant inventory.

The influence of markedness on consonant cluster acquisition

Some consonant clusters are more 'marked' than others. According to Eckman (1977), marked structures appear less frequently in the world's languages and so these structures are inherently more difficult to process or acquire. Empirical research has also discovered some universally marked consonant cluster structures. First, consonant clusters in which the component consonants are close in sonority values have been found to be difficult to learn (Broselow & Finer, 1991; Carlisle, 2001; Hancin-Bhatt & Bhatt, 1997). Sonority is the inherent loudness of a consonant and Broselow and Finer (1991) ranked sonority as stops < fricatives < nasals < liquids < glide. Therefore, they suggested that the 'fr' cluster was harder than the 'pr' cluster because /f/ and /r/ had a smaller sonority difference than /p/ and /r/. Second, learners have been found to be less accurate at producing consonant clusters which violate the Sonority Sequencing Principle (SSP) (Eckman, 1991; Eckman & Iverson, 1993). The SSP requires the consonants to be arranged in such a way to form an ideal sonority curve ascending from onset to nucleus and descending from nucleus to coda (Eckman, 1991; Eckman & Iverson, 1993). Third, quite a few studies have converged on the observation that learners are less accurate at producing syllable coda clusters than syllable onset clusters (Anderson, 1987; Hancin-Bhatt & Bhatt, 1997; Sato, 1984). Finally, it has also been commonly found that longer clusters, i.e. clusters consisting of more consonants, are more difficult to produce than shorter clusters (Abrahamsson, 1999; Carlisle, 2001; Hancin-Bhatt, 2000; Ioup & Weinberger, 1987). It is unknown whether the above patterns can be observed in L3 consonant cluster acquisition, as L3 acquisition involves more complex CLIs than L2 acquisition.

Cross-linguistic influences on L3 phonological acquisition

Over the past few decades, L3 theories have formed different views about the possibilities of CLI. Among these, the Typological Primacy Model (Rothman et al., 2010) predicts predominant wholesale transfer from a typologically similar language to the L3 in the initial stage, while the L2 Status Factor (Bardel & Falk, 2007) hypothesises primary transfer from the L2 to the L3. In comparison, the Cumulative-Enhancement Model (Flynn et al., 2004) regards both L1 and L2 as facilitative in L3 acquisition. More recently, the Linguistic Proximity Model (Westergaard & Rodina, 2017) and the Scalpel Model (Slabakova, 2017) predict property-by-property CLI from both of the learners' background languages to L3. The Scalpel Model also includes factors other than L1 and L2 transfer. These may include processing complexity, availability of clear unambiguous input, prevalent use, misleading input, and construction frequency. These predictions are mainly based on morphosyntactic research, but may also be applied to L3 phonology. Therefore, for L1 Cantonese-L2 English speakers learning L3 German consonant clusters, the Typological Primacy Model and L2 Status Factor predict a systematic transfer from L2 English phonology to L3 German. In comparison, the Cumulative-Enhancement Model, the Linguistic Proximity Model and the Scalpel Model predict that learners selectively transfer L1 Cantonese and L2 English phonetic features to L3 German, while the Linguistic Proximity Model and the Scalpel Model allow for negative transfer as well.

In addition to theoretical research, empirical L3 phonological studies have also provided rich findings regarding CLI. A number of L3 speech studies have observed complex CLIs from L1 and L2 to L3, varying with the exact target phonological feature. These include the foreign accent studies on Polish–German–English trilinguals (Wrembel, 2010, 2012), the metaphonological awareness study on Polish–French–English trilinguals (Wrembel, 2015), phonological error analysis of Cantonese–Mandarin–English trilinguals (Chen & Han, 2019), and a range of studies on L3 vowels (Kopečková et al., 2016; Lechner & Martin, 2014; Lipińska, 2015; Missaglia, 2010; Onishi, 2016; Sypiańska, 2016). In comparison, there have also been studies supporting major transfer from either L1 (Eika & Hsieh, 2017; Llama & Cardoso, 2018; Patience, 2018) or L2 (Gut, 2010; Llama et al., 2010). The above studies have covered a variety of L3 speech features, but there have not been any studies on L3 consonant clusters. Accurate pronunciation of L3 consonant clusters requires the acquisition of both individual L3 consonants and L3 syllable structures. As a segmental-suprasegmental interface phenomenon, consonant clusters may therefore offer interesting insights into L3 phonology.

The present study

The present study focuses on the acquisition of L3 German consonant clusters by Cantonese–English bilingual learners whose L2 allows consonant clusters but whose L1 does not. Given the previous findings that language background can influence consonant cluster acquisition, the study also intends to inquire how L3 learners' L1 and L2 work together to influence L3 consonant cluster production. At the same time, since acquisition difficulty has been shown by previous studies to be influenced by the markedness of the clusters, markedness effects are also tested. The following research questions will be addressed in the present study:

1. To what extent is L3 consonant cluster production influenced by L1 and L2?
2. How does markedness influence L3 consonant cluster production?
3. Are there other factors affecting the production of L3 consonant clusters?

Method

Participants

Twenty-six Cantonese–English bilinguals learning L3 German at the Chinese University of Hong Kong took part in the experiment. The L3 learners spoke Cantonese as their L1 and had been exposed to English-speaking environments. They had started learning L2 English at the age of three ($SD = 0.7$ years) and their mean IELTS score was 6.8 ($SD = 0.98$). After starting university, they began attending weekly L3 German lessons of 1.5 h. At the time of testing, they had been learning German for two years and their L3 German proficiency was confirmed by their instructors to be at the A2-B1 level in the Common European Framework. We also collected information on learners' individual L3 activities. Twelve of the L3 speakers reported themselves as engaging in extra-curricular German-learning activities such as talking to German-speaking friends, reading German books, and watching German movies. Nearly half of them had spent one to six months in German-speaking countries, except for one speaker (S26) who had stayed in Germany for one year. Detailed participant information is provided in Appendix B.

Procedure

The participants were recorded reading the phrase 'Ich sage das Wort __', with the keyword appearing in the final focus position. The word list, shown in Appendix A, included 109 German words containing 17 onset and 21 coda clusters. Of the onset clusters, 14 were CC clusters and three were CCC clusters. The coda clusters consisted of 14 CC clusters, 6 CCC clusters and one CCCC cluster. The reading material was provided for the participants on a piece of paper, with each word appearing twice in a randomised order. Prior to the recording, participants familiarised themselves with the material and were allowed to ask questions or consult dictionaries in case they did not know the word. Then the participants read the material in a natural manner and their productions were recorded with a portable recorder (44.1 kHz/16bit). Two native German speakers were recorded reading the same material for reference. The native speakers were professional German teachers in Hong Kong with rich teaching experience and phonological awareness. They recorded their read speech in a Northern Standard German accent at a natural speed.

Data analysis

Participants' productions were transcribed separately using IPA narrow transcription by the first author, who had had systematic training in linguistics and reached C1 level (advanced) in German, and a native German speaker, who was a professional German teacher with adequate knowledge of German phonology. The first round of transcription generated a 78.8% inter-rater agreement. To resolve the disagreements, the disputed items were listened to carefully and transcribed again separately by the two transcribers for comparison. In the second round of comparison, the agreement rate reached 98.5%. The remaining disputed items were discarded to obtain the final unified transcriptions.

With reference to standard German pronunciation, we classified learners' incorrect renditions of German consonant clusters into three major types: *insertion*, *substitution,* and *reduction*, as summarised in Table 1. Among these, *insertion* was adding any segment (e.g. /ps/ → [pɪs]), regardless of consonant or vowel, in any position of the consonant cluster. *Reduction* was deleting consonants (e.g. /lts/ → [ts]) or using one sound to replace two or three consonants (e.g. /tsv/ → [zv]). Natural lenition processes in German such as /mpt/→ [mt] were not counted as reduction errors. *Substitution* was replacing a consonant with a completely different segment (e.g. /mt/→ [nt]) or changing the pronunciation of a consonant (e.g. /lp/→ [ɫp]). The three types of errors sometimes overlapped, which means that one erroneously produced consonant cluster could be counted as both *substitution* and *insertion* (e.g. /kn/ → [gən]).

Based on the above coding, we conducted our two-dimensional analyses: error analysis and accuracy analysis. To answer the first research question on CLI, we examined the various types of learners' production errors and related them to the learners' L1 and L2 systems. In addition, we quantified the overlaps between the L1, L2 and L3 consonant systems and modelled the contribution of cross-linguistic overlap to L3 production accuracy. To answer the second question of markedness, we analysed the various markedness factors (i.e. sonority distance, typological markedness of consonants, sonority sequencing, length of consonant clusters, and onset/coda distinction) in relation to L3 consonant cluster error types and accuracy. To answer the third question about other contributing factors, we also discussed language experience, proficiency and articulatory constraints that might influence L3 consonant cluster production.

Results

Overview

The overall performance in L3 consonant cluster production was not high, for a task that simply involved reading out the designated words. The L3 learners' mean accuracy on the

Table 1. Consonant cluster modification strategies.

Type	Definition
Insertion	Adding vowels or consonants before, between, or after a consonant cluster.
Reduction	Deleting one or more consonants or combining several consonants to reduce the number of consonants in a cluster.
Substitution	Replacing individual consonants in a cluster with another consonant or realising the consonants in a non-native way.

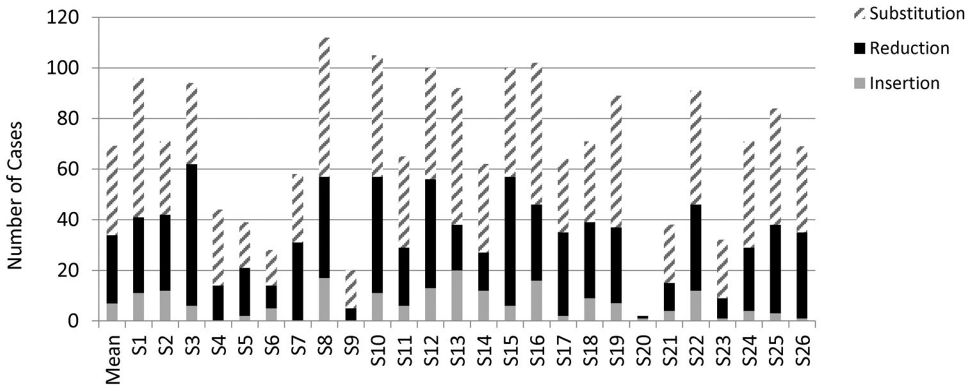

Figure 1. An overview of cluster repair strategies by the participants.

tested clusters was 68.02% ($SD = 13.13\%$), which means that they mispronounced nearly one-third of the L3 consonant clusters. Their mispronunciations were classified into the three types and summarised in Figure 1. It could be observed that despite individual differences, *reduction* and *substitution* systematically outnumbered *insertion*. According to the coding scheme, the three repair strategies can co-occur in one single consonant cluster, and they are independent of each other, so one-way ANOVAs can be applied to compare the three strategies. The ANOVA model was significant, $F(2, 75) = 38.565$, $p < .001$. A Tukey HSD test suggested that *reduction* and *substitution* significantly outnumbered *insertion* (ps < .001). Each repair strategy was then analysed separately.

The most frequently used strategy for producing L3 clusters was substitution, which accounted for 50% of the errors. Substitution occurred when learners replaced an individual consonant with a similar consonant in a cluster. Learners consistently replaced particular consonants with another consonant, irrespective of syllable position. As shown in Figure 2, the most commonly mispronounced consonants were /ʃ/, /v/, and /l/, which

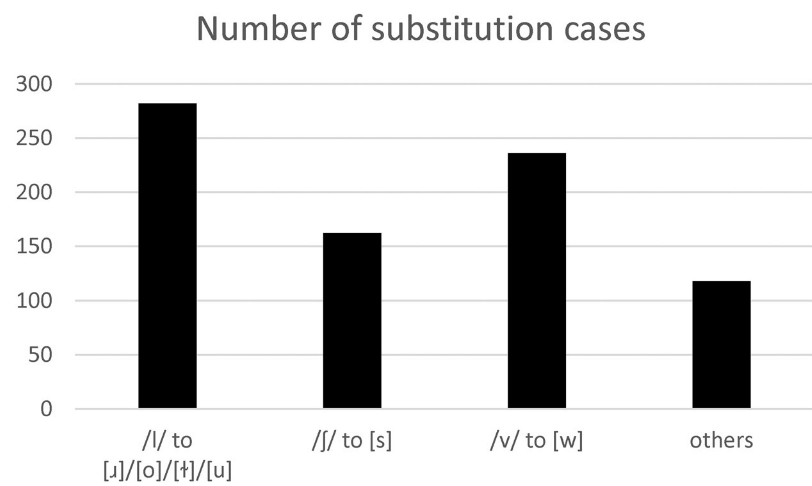

Figure 2. Number of substitution cases.

constituted 85% of all cases. The /l/ in coda clusters was modified by almost all participants. The German post-vocalic /l/ is a clear [l], which was often produced as [ɹ], [u], [o], or a dark [ɫ]. The /ʃ/ in onset clusters was often replaced by [s], despite the fact that English also has /ʃ/ in syllable onsets (e.g. 'shoe' /ʃu/). Also, the /v/ in onset clusters was usually replaced by [w].

Another common L3 cluster production strategy was reduction, explaining 40% of the errors. Reduction includes two types: deletion and coalescence, the former making up the majority of cases (93%). As shown in Figure 3, onset and coda positions show different deletion patterns, in that codas induced more cases of deletion. A chi-square test of independence was performed to examine the relationship between syllable position and deletion pattern. The model was significant, X^2 (1, $N = 621$) = 42.4, $p < .001$, which shows that codas were produced with more deletion than onsets, and that less sonorous consonants were deleted more often than more sonorous consonants. Further exploration of the data suggested that orthography played a significant role in learners' deletion behaviours. For instance, the onset letter string *kn* should be pronounced as [kn] in German, but as [n] in English. L3 learners applied the English spelling rule so they pronounced *kn* as [n], leading to the deletion of a less sonorous consonant. Such cases accounted for 73% of all deletion cases. Also, 55% of the investigated L3 coda clusters ended with voiceless stops (e.g. /mt/, /lp/, /nt/). These stops, which were also less sonorous consonants, tended to be deleted by the L3 learners, whose L1 Cantonese phonology only allows unrealised final stops. Aside from deletion, coalescence also occurred occasionally, but the latter only took 7% of the total reduction cases. Coalescence was also motivated by German-English orthographic mismatch. For instance, the letter string *ps* in onset is pronounced as [ps] in German and as [s] in English, and learners used the English rule so they changed the *ps* to [s].

The least used production strategy was insertion, but it still formed a substantial portion of the errors (10%). Insertion is adding any vowels and consonants to a given consonant cluster. Figure 4 shows that learners usually added lax vowels /ɪ/ and /ə/, and voiceless obstruents such as /p/, /t/ and /s/. Learners' cluster insertion strategies also exhibited an onset/coda asymmetry, as more instances of insertion appeared in coda clusters than in onset clusters.

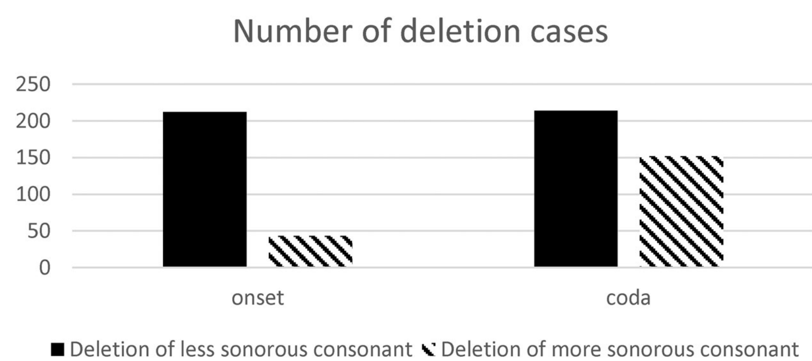

Figure 3. Number of deletion cases in onset and coda position.

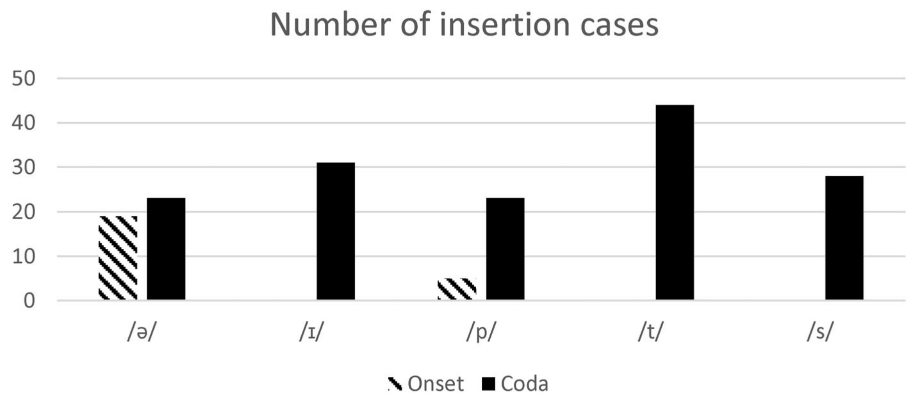

Figure 4. Number of inserted segments in onset and coda positions.

Among the different types of insertion, vowel epenthesis is a typical one, involving the insertion of a vowel to break up a complex consonant cluster. Pearson correlation analysis found that the learners' overall accuracy and frequency of using vowel epenthesis were negatively correlated ($r = -.75$, $p < .001$), while accuracy was not significantly correlated with any other simplification method (all $ps > .05$). As shown in Figure 5, less accurate individuals generally applied vowel epenthesis more often. Thus, vowel epenthesis is related to proficiency.

Influence of L1 and L2 on L3 consonant cluster production

Simultaneous L1 and L2 influences were observed in the L3 learners' cluster repair strategies. Reduction occurs when learners use L2 English spelling to produce German

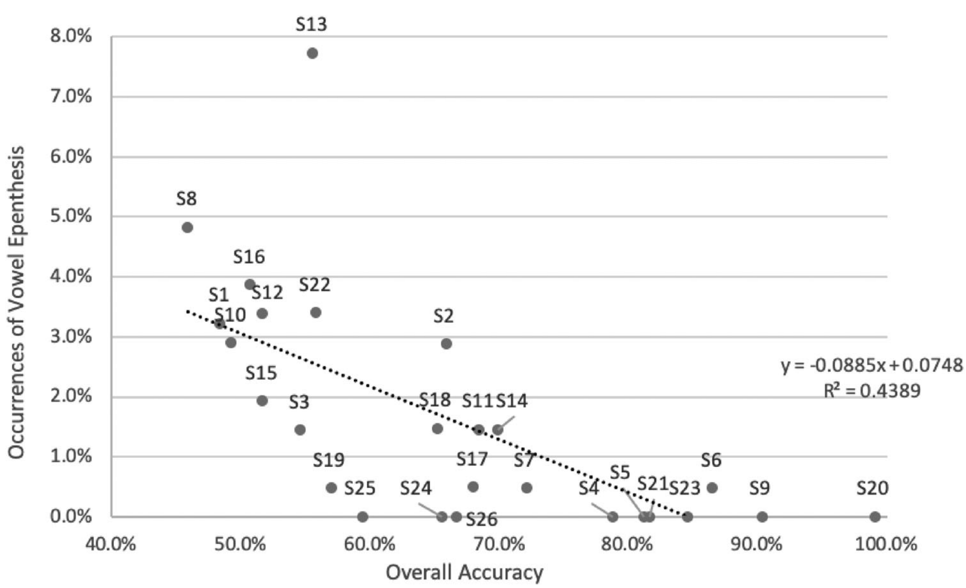

Figure 5. Correlation between the percentages of vowel epenthesis and accuracy.

clusters. As for substitution, the production of German clear coda /l/ is conditioned by learners' L1 and L2. Clear coda /l/ does not exist in L1 Cantonese and L2 English, and the replacement of clear /l/ with [o] and [u] results in legal phonological combinations in Cantonese, while the replacement of clear /l/ with dark [ɫ] and [ɹ] results in legal phonological combinations in English. Also, the replacement of /s/ in onset clusters can be explained by L2 English. Onset letter combinations like *sl, sm, sn, sp, st* are common in English, while in German, the *s* in these strings is pronounced as [ʃ] instead of [s]. The replacement of /v/ with [w] can be explained from two aspects. First, Cantonese has no /v/ and learners used the nearest sound [w] to pronounce /v/. Such replacement is commonly found in Hong Kong English as well (Chan & Li, 2000; Hung, 2000). Another possibility is L2 orthographic transfer, as the letter *w*, which is pronounced as [v] in German, is instead pronounced as [w] in English. Hence, the reduction and substitution of L3 clusters usually resulted from L1 and L2 phonetic and orthographic transfer.

The mean accuracies of the L3 consonant clusters tested are listed in Table 2, showing significant variation across clusters. It is noted that some L3 clusters contain more L1/L2 segments while others contain fewer L1/L2 segments, and it is worth testing whether this can contribute to the accuracy of different L3 clusters.

To quantify the degree of overlap between an L3 consonant cluster and any L1 and L2 consonants, we used Seg_L1, Seg_L2, Cluster_L2 to describe the overlap at segmental and syllabic levels.

$$\text{Seg\_L1} = \text{number of legal L1 consonants} \,/\, \text{length of cluster} \tag{1}$$

$$\text{Seg\_L2} = \text{number of legal L2 consonants} \,/\, \text{length of cluster} \tag{2}$$

$$\text{Cluster\_L2} = \text{whether the target cluster exists in L2 English} \tag{3}$$

Table 2. Error types and the overall accuracy (%, INS = insertion, RED = reduction, SUB = substitution, ACC = overall accuracy).

Onset cluster	INS	RED	SUB	ACC	Coda cluster	INS	RED	SUB	ACC
bl	0	1	1	98	ft	3	3	0	95
fl	3	2	6	88	kt	14	10	5	71
gl	0	1	3	96	lf	0	14	52	34
kl	0	0	4	96	ln	8	56	1	34
kn	4	29	10	56	lp	4	21	47	28
kv	1	1	88	11	ls	10	7	44	39
ps	1	73	21	5	lt	1	10	41	47
sk	0	4	22	74	mt	0	11	3	86
ʃl	1	1	8	90	nf	7	2	4	87
ʃm	0	1	8	92	ns	3	8	1	87
ʃn	0	0	4	96	nʃ	7	2	1	90
ʃp	1	0	29	69	nt	1	16	3	80
ʃt	0	0	25	75	pʃ	16	4	12	68
ʃv	1	0	39	60	ʃt	5	13	16	66
pfl	6	37	1	56	fst	2	41	12	45
tsv	1	31	42	26	lmt	6	28	2	65
					lts	12	25	25	36
					m(*p*)f	14	3	8	74
					m(*p*)t	0	6	4	90
					nts	3	11	1	86
					ltst	0	62	8	31

Table 3. The presence of L1 and L2 elements in each L3 consonant cluster.

Onset cluster	Seg_L1	Seg_L2	Cluster_L2	Coda cluster	Seg_L1	Seg_L2	Cluster_L2
bl	1	1	1	ft	0.5	1	1
pl	1	1	1	kt	1	1	1
fl	1	1	1	lf	0	1	1
gl	1	1	1	ln	0.5	1	0
kl	1	1	1	lp	0.5	1	1
kn	1	1	0	ls	0	1	1
kv	0.5	1	0	lt	0.5	1	1
ps	1	1	0	mt	1	1	0
sk	1	1	1	nf	0.5	1	0
ʃl	0.5	1	0	ns	0.5	1	1
ʃm	0.5	1	0	nʃ	0.5	1	0
ʃn	0.5	1	0	nt	1	1	1
ʃp	0.5	1	0	pʃ	0.5	1	0
ʃt	0.5	1	0	ʃt	0.5	1	1
ʃv	0	1	0	fst	0.33	1	0
pfl	1	1	0	lmt	0.67	1	0
tsv	0.67	1	0	lts	0.33	1	1
				mpf (mf)	0.33	1	1
				mpt (mt)	0.67	1	1
				nts	0.67	1	1
				ltst	0.5	1	0

In (1) and (2), Seg_L1 and Seg_L2 measured the proportion of legal L1 consonants and L2 consonants within an L3 consonant cluster. The determination of legal consonants was position-sensitive, which means that onset and coda consonants were treated separately. Take the coda cluster /fst/ as an example. Cantonese syllable codas permit /t/ but not /f/ or /s/, so this L3 cluster has a Seg_L1 value of 0.33. In (3), Cluster_L2 refers to whether the cluster exists in English (0 = no, 1 = yes). There was no Cluster_L1 because Cantonese has no consonant clusters. The results of this coding scheme are presented in Table 3.

Based on the coding, logistic regression analysis was performed to assess the impact of Seg_L1, Seg_L2 and Cluster_L2 on the likelihood that a consonant cluster would be produced correctly or incorrectly. The binary dependent variable was coded as 1 (correct) and 0 (incorrect). The model (χ^2 (df = 2, n = 5252: correct = 3530: incorrect = 1722) = 230.18, p < 0.0001) showed that the accuracy of a consonant cluster was determined by Seg_L1 (β = 1.15 (0.10), $p < .001$) and Cluster_L2 ($\beta = 0.56$ (0.06), $p < .001$). Further analysis of odds ratios suggested that if an L3 cluster contained one more L1 segment, the accuracy would increase about twofold, whereas if an L3 cluster existed in L2, the odds of it being correct would increase by 75%. The contribution of Seg_L2 was not significant ($p > .05$), which is reasonable because all the tested L3 consonants consisted of L2 segments. Therefore, the results indicate simultaneous L1 and L2 transfer. An L3 cluster was produced with higher accuracy if it contained more legal L1 segments or if it was a legal L2 cluster.

Influence of markedness on L3 consonant cluster errors

Some L3 consonant cluster production errors cannot be explained by transfer, but markedness can offer an explanation of the results. In terms of reduction, learners more often reduced coda clusters than onset clusters, and this confirms the onset-coda asymmetry (Hancin-Bhatt & Bhatt, 1997). Insertion also occasionally occurred in L3 production. The

Table 4. Sonority distances of the CC consonant clusters.

Cluster	Sonority distance	Cluster	Sonority distance	Cluster	Sonority distance
ʃp	1	sk	1	ns	1
ʃv	0	pl	3	mt	2
kl	3	kn	2	lt	3
ʃn	1	ps	1	ʃt	1
ʃt	1	nʃ	1	lf	2
ʃm	1	ft	1	nt	2
kv	1	mf(mpf)	1	kt	0
ʃl	2	pʃ	1	lp	3
bl	3	nf	1	ln	1
gl	3	mt(mpt)	2		
fl	2	ls	2		

added vowels had a neutral place of articulation. These vowels are unmarked, which means they take the least effort to articulate. The added consonants were voiceless stops and fricatives, which are also recognised in the literature as unmarked consonants. The addition of vowels can break a complex syllable into several simple syllables which eases articulation, as the learners' L1 only allows simple syllable structures.

The influence of markedness factors on production accuracy was analysed in relation to sonority distance, typological markedness of consonants, sonority sequencing, length of consonant clusters, and onset/coda distinction.

The first markedness factor under investigation was sonority distance. Based on the sonority values in Broselow and Finer (1991) (stops = 1, fricatives = 2, nasals = 3, liquids = 4, glides = 5), we calculated the sonority distance for each CC cluster (Table 4). Then sonority distance was included as the predictor of accuracy in a logistic regression model (χ^2 (df = 1, n = 4526: correct = 3151: incorrect = 1375) = 38.98, $p < 0.0001$). The model suggested that the accuracy of L3 CC clusters was significantly predicted by sonority distance ($\beta = 0.23$ (0.04), $p < .001$). One unit increase in sonority distance could raise the odds of the accurate pronunciation of CC clusters by 26%.

Next, the typological markedness of consonants was examined in relation to accuracy. According to Eckman and Iverson's (1993) typological markedness hierarchy, fricatives are more marked than stops, voiced stops are more marked than voiceless stops, and voiced fricatives are more marked than voiceless fricatives. Also, according to Clements (1990) Sequential Markedness Principle, 'For any two segments A and B and any given context X_Y, if A is less marked than B, then XAY is less marked than XBY'. Thus, the relative difficulty of the L3 German consonant clusters can be derived. Table 5 shows the

Table 5. Predictions on the difficulty of consonant clusters based on typological markedness. (Accuracies are in parentheses).

Markedness prediction			Results
ʃp (0.7), ʃt (0.7)	to be easier than	ʃv (0.6)	Not supported
kt (0.7)		ft (1.0)	Not supported
kt (0.7)		kv (0.1)	Supported
pl (0.9), kl (1.0)		bl (1.0), gl (1.0)	Not supported
lt (0.5) lp (0.3)		ls (0.4), lf (0.3)	Supported
nt (0.8)		ns (0.9)	Not supported
mpt/mt (0.9)		mpt/mf (0.7)	Supported
bl (1.0), gl (1.0)		fl (0.9)	Not supported

markedness predictions on the relative difficulty and the actual accuracy of consonant clusters in the experiment. It can be observed from Table 5 that the typological markedness was at chance in predicting the acquisition difficulty of the L3 consonant clusters. Therefore, markedness cannot explain L3 consonant cluster acquisition patterns in this study.

Finally, sonority sequencing (sonority reversal = −1, sonority plateau = 0, optimal sonority sequencing = 1), cluster length, and onset/coda asymmetry (onset = 0, coda = 1) factors were analysed together using logistic regression. Onset/coda position was not a significant predictor of accuracy ($p > .05$) and was excluded from the final model. The final model (χ^2 (df = 2, n = 5356: correct = 3802: incorrect = 1554) = 130.94., $p <$ 0.0001) showed that the accuracy of L3 consonant clusters was significantly affected by cluster length ($\beta = -0.83$ (0.07), $p < .001$) and sonority sequencing ($\beta = -0.12$ (0.04), $p = .003$). An increase of one segment in a consonant cluster would decrease the odds of being correct by 56%. Violation of sonority sequencing would decrease the odds of being correct by 11%. Thus, length and sonority sequencing did indeed affect the production of L3 clusters.

Among the above markedness factors investigated, sonority distance, sonority sequencing and length of consonant cluster contributed to accuracy. An L3 cluster is more likely to be accurately produced if it is short, obeys the sonority sequencing curve, and contains consonants with a large sonority distance.

Other factors influencing L3 consonant cluster errors

Finally, the insertion of consonants in L3 cannot be explained by transfer for markedness. Extra consonants in L2 production were also found in another study on Hong Kong English, and the study provided articulatory explanations (Setter & Deterding, 2003). In the current study, consonant epenthesis may also be articulation-based. For example, the release of air in /k/ and the constriction of air in /t/ in the alveolar region may create an epenthetic [s], causing the /kt/ → [kts] error. Another finding on insertion was that the less accurate individuals generally used more vowel epenthesis. This observation is consistent with Ding (2014), who also found that low-proficiency L2 German learners of L1 Mandarin used vowel epenthesis more often than high-proficiency learners did in coda consonant production. Vowel epenthesis differs from other simplification strategies as it changes a complex syllable into several simple syllables. Using vowel epenthesis may denote that learners are having difficulty in producing complex syllables. Thus, the finding suggests that low-proficiency learners in this study have not yet mastered L3 German syllable structures, and that the acquisition of complex syllable structures progresses with proficiency.

In addition, the individual variation between different L3 speakers is not related to either transfer or markedness. The L3 speakers' mean production accuracies were analysed with respect to their L3 experience. A logistic regression model of speakers' accuracy was built with length of time studying German, time spent on German outside the classroom, and overseas experience in German-speaking countries as independent variables (χ^2 (df = 3, $n = 5349$: correct = 3550: incorrect = 1799) = 35.14, $p < 0.0001$). The model showed that learners' accuracy was predicted by the extra time they had spent in German-speaking countries ($\beta = 0.96$ (0.17), $p < .001$). With one more month spent in a

German-speaking country, participants' accuracy could increase 2.6 times. There was a tendency that using German outside the classroom might lead to higher accuracy in production, but the effect was marginal ($\beta = 0.12$ (0.07), $p = .06$). Meanwhile, learners' accuracy was not affected by length of years spent studying German ($p > 0.5$), indicating that the variation of 1.5–3 years of classroom instruction did not impact on learners' L3 consonant cluster production patterns. In brief, the patterns show that the L3 learners who had spent more time in German-speaking countries were more likely to achieve higher accuracy in German consonant cluster production.

Discussion

The study examined error types and accuracy in the production of L3 German consonant clusters. With regard to the first research question, the findings suggest that L1 and L2 form a combined force to influence the production of L3 German. The findings of the present study are consistent with the Linguistic Proximity Model (Westergaard & Rodina, 2017) and the Scalpel Model (Slabakova, 2017), which hypothesised property-by-property CLIs in both facilitative and non-facilitative manners. First, different L3 consonant clusters vary in accuracy: the accuracy is higher if an L3 cluster exists in L2 and if it contains individual L1 consonants. This individual variation within L3 clusters is unlikely to be the result of a wholesale transfer from L1 and L2. Instead, it seems that L1 and L2 exert different influences on each L3 consonant cluster instead of on the whole L3 consonant system. Besides, we have found evidence of non-facilitative transfer from L1 and L2 to L3 consonant cluster production. For instance, the L3 speakers have the [ps] → [s] and [ks] → [s] reduction errors, because *ps* and *kn* onsets are pronounced as [ps] and [ks] in German, but as [s] and [n] in English. Negative transfer from L2 orthography to L3 speech has also been demonstrated in other studies (Kamiyama, 2007; Patience, 2018). Patience (2018) noticed a substitution of L3 Spanish rhotics with L2 English [ɹ] by Mandarin-speaking learners under the influence of L2 English orthographic rules. Kamiyama (2007) found negative influence of L2 orthography in Japanese-English bilingual learners' production and perception of L3 French vowels /ø/ and /ɛʀ/. In addition to negative transfer, there is also evidence of positive transfer, in that the learners used L2 knowledge to produce L3 clusters, and they were more accurate at L3 clusters that also exist in L2. Therefore, consistent with the Linguistic Proximity Model (Westergaard & Rodina, 2017) and the Scalpel Model (Slabakova, 2017), the study shows that L3 consonant cluster production experiences transfer from L1 and L2 at the feature level, in both facilitative and non-facilitative ways.

As for the second research question, the current study found that markedness does play a role in L3 phonological acquisition. The L3 learners were more accurate at producing consonant clusters which were shorter in length, contained consonants that stood further apart on the sonority hierarchy (Broselow & Finer, 1991), and obeyed the Sonority Sequencing Principle (Eckman & Iverson, 1993). These consonant clusters have been demonstrated by many previous L1 and L2 acquisition studies as universally easier to produce. Also, markedness explains many of the learners' cluster rendition phenomena. For instance, learners more often simplified coda consonant clusters than they did onset consonant clusters, indicating that codas are harder than onsets to produce accurately, which is confirmation of previously observed universal onset-coda asymmetry (e.g.

Sato, 1984). The insertion of vowels and consonants such as /ə/, /ɪ/ and /p/ is another piece of evidence of the markedness effect, as these segments take little effort to articulate and are regarded as unmarked. The influence of markedness found in the present L3 study echoes another study on the acquisition of an artificial L3 (Antoniou et al., 2015). The bilingual learners in that study were universally better at Mandarin-like L3 retroflexes regardless of their linguistic background, showing that some unmarked L3 phonetic features are inherently easier to learn.

Finally, L3 consonant cluster production is affected by factors other than markedness and transfer, and the answer to the third research question is positive. To begin with, some of the L3 consonant cluster errors, such the insertion of an extra final [s] after coda /kt/, are motivated by the coordination of articulators, which is not related to markedness or transfer. Moreover, the individual variation between different L3 speakers is better explained by proficiency and language experience factors, instead of markedness or transfer. Although the participants were from the same level of German course, some of them had spent more time in Germany and more time on German outside the classroom, and these naturally contributed to their learning outcomes. The analysis of cluster production accuracy reveals the effectiveness of overseas experience in L3 speech learning. The longer participants had stayed in German-speaking countries, the more accurate they were at consonant cluster production. Extracurricular language usage also has a marginal effect on L3 production accuracy, and extracurricular hours could possibly facilitate L3 consonant cluster acquisition. More importantly, individual variation was observed in participants' cluster simplification strategies. The high-performing L3 learners used vowel epenthesis less often than the low-performing learners did, while this difference was not found in other cluster modification strategies like substitution and reduction. Unlike substitution and reduction, vowel epenthesis is a method to simplify syllable structure, so it seems that low-performing L3 learners have not yet mastered the L3 German complex syllable structures. For these L3 learners, they either failed to transfer their L2 experience of complex syllable structures to L3 speech learning, or had not fully acquired the L2 complex syllable structures in the first place. The second explanation is less likely as the participants were all advanced English L2 speakers. In the meantime, since vowel epenthesis constituted only a small proportion of cluster modification cases, while substitution and reduction were the main strategies used by the L3 learners, it can be inferred that the majority of L3 learners may have successfully acquired the L3 complex syllable structures, either because of the facilitation of L2 knowledge on complex syllable structures, or due to successful L3 phonological acquisition.

Conclusion

This study sets out to investigate CLIs on the acquisition of L3 German consonant clusters by L1 Cantonese-L2 English bilinguals. Analysis of production accuracy and modification strategies reveals that different L3 consonant clusters go through various degrees of feature-level transfer from L1 and L2. L3 learners rely on the nearest L1 and/or L2 features to produce L3 clusters, which results in both positive and negative transfers. The L3 consonant clusters that overlap with L1 and/or L2 are often produced accurately, whereas the L3 consonant clusters that contain similar but non-identical L1 and/or L2 segments tend to induce inaccurate production. Specifically, the mismatch between L2 English and L3

German spelling rules contributes to a large proportion of the erroneous L3 consonant cluster production. At the same time, the successful acquisition of L3 consonant clusters also depends on the inherent difficulty of the target structure and individual language experience. For instance, long L3 consonant clusters and those that violate the sonority sequencing principles are universally difficult to acquire. As for language experience, individuals who have spent time in German-speaking countries exhibit better performance in L3 consonant cluster production. These many factors work together with cross-linguistic influence to shape the acquisition of L3 speech.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

Abrahamsson, N. (1999). Vowel epenthesis of /sC(C)/ onsets in Spanish/Swedish interphonology: A longitudinal case study. *Language Learning*, *49*(3), 473–508. https://doi.org/10.1111/0023-8333.00097

Anderson, J. (1987). The markedness differential hypothesis and syllable structure difficulty. In G. Ioup, & S. Weinberger (Eds.), *Interlanguage phonology: The acquisition of a second language sound system* (pp. 279–291). Newbury House.

Antoniou, M., Liang, E., Ettlinger, M., & Wong, P. C. M. (2015). The bilingual advantage in phonetic learning. *Bilingualism: Language and Cognition*, *18*(4), 683–695. https://doi.org/10.1017/S1366728914000777

Bardel, C., & Falk, Y. (2007). The role of the second language in third language acquisition: The case of Germanic syntax. *Second Language Research*, *23*(4), 459–484. https://doi.org/10.1177/0267658307080557

Broselow, E., & Finer, D. (1991). Parameter setting in second language phonology and syntax. *Second Language Research*, *7*, 35–59. https://doi.org/10.1177/026765839100700102

Carlisle, R. S. (2001). Syllable structure universals and second language acquisition. *IJES, International Journal of English Studies*, *1*(1), 1–19. https://doi.org/10.6018/ijes.1.1.47581

Chan, A. Y. W. (2006). Cantonese ESL learners' pronunciation of English final consonants. *Language, Culture and Curriculum*, *19*(3), 296–313. https://doi.org/10.1080/07908310608668769

Chan, A. Y. W., & Li, D. C. S. (2000). English and Cantonese phonology in contrast: Explaining Cantonese ESL learners' English pronunciation problems. *Language, Culture and Curriculum*, *13*(1), 67–85. https://doi.org/10.1080/07908310008666590

Chen, H. C., & Han, Q. W. (2019). L3 phonology: Contributions of L1 and L2 to L3 pronunciation learning by Hong Kong speakers. *International Journal of Multilingualism*, *16*(4), 492–512. https://doi.org/10.1080/14790718.2019.1573901

Clements, G. N. (1990). The role of the sonority cycle in core syllabification. In J. Kingston, & M. Beckman (Eds.), *Papers in laboratory phonology I: Between the grammar and physics of speech* (pp. 283–333). Cambridge University Press.

Ding, H. (2014). Zhongguo daxuesheng deyu yinjiewei fuyin fayin de shiyan yanjiu [An acoustic study on Chinese students' pronunciation of German syllable consonant codas]. *Journal of School of Chinese Language and Culture, Nanjing Normal University*, *3*, 176–185. https://doi.org/10.3969/j.issn.1008-9853.2014.03.033

Eckman, F. R. (1977). Markedness and the contrastive analysis hypotheis. *Language Learning*, *27*(2), 315–330. https://doi.org/10.1111/j.1467-1770.1977.tb00124.x

Eckman, F. R. (1981). On predicting phonological difficulty in second language acquisition. *Studies in Second Language Acquisition*, *4*(01), 18. https://doi.org/10.1017/S0272263100004253

Eckman, F. R. (1991). The structural conformity hypothesis and the acquisition of consonant clusters in the interlanguage of ESL learners. *Studies in Second Language Acquisition*, *13*(1), 23–41. https://doi.org/10.1017/S0272263100009700

Eckman, F. R., & Iverson, K. (1993). Sonority and markedness among onset clusters in the interlanguage of ESL learners. *Second Language Research*, *9*(3), 234–252. https://doi.org/10.1177/026765839300900302

Eika, E., & Hsieh, Y. (2017). On Taiwanese pupils ability to differentiate between English / l / and / r /: A study of L1 / L2 cross-language effects. *First Language*, *37*(5), 500–517. https://doi.org/10.1177/0142723717709106

Flynn, S., Foley, C., & Vinnitskaya, I. (2004). The cumulative-enhancement model for language acquisition: Comparing adults' and children's patterns of development in first, second and third language acquisition of relative clauses. *International Journal of Multilingualism*, *1*(1), 3–16. https://doi.org/10.1080/14790710408668175

Gut, U. (2010). Cross-linguistic influence in L3 phonological acquisition. *International Journal of Multilingualism*, *7*(1), 19–38. https://doi.org/10.1080/14790710902972248

Hancin-Bhatt, B. (2000). Optimality in second language phonology: Codas in Thai ESL. *Second Language Research*, *16*(3), 201–232. https://doi.org/10.1191/026765800671362605

Hancin-Bhatt, B., & Bhatt, R. M. (1997). Optimal L2 syllables: Interactions of transfer and developmental effects. *Studies on Second Language Acquisition*, *19*(3), 331–378. https://doi.org/10.1017/S0272263197003033

Hung, T. T. N. (2000). Towards a phonology of Hong Kong English. *World Englishes*, *19*(3), 337–356. https://doi.org/10.1111/1467-971X.00183

Ioup, G., & Weinberger, S. (1987). *Interlanguage phonology: The acquisition of a second language sound system*.

Kamiyama, T. (2007). *Acquisition of French vowels by Japanese-speaking learners: Close and close-mid rounded vowels*. Paper presented at the L3 Phonology Satellite Workshop of ICPhS XVI.

Kopečková, R., Marecka, M., Wrembel, M., & Gut, U. (2016). Interactions between three phonological subsystems of young multilinguals: The influence of language status. *International Journal of Multilingualism*, *13*(4), 426–443. https://doi.org/10.1080/14790718.2016.1217603

Lechner, S., & Martin, K. (2014). *Phonetic transfer onto L3 English in subtractive bilinguals*. Paper presented at SLE 2014 Workshop on Advances in the Investigation of L3 Phonological Acquisition.

Lipińska, D. (2015). Production of L3 vowels: Is it possible to separate them from L1 and L2 sounds? *Research in Language*, *13*(1), 77–92. https://doi.org/10.1515/rela-2015-0011

Llama, R., & Cardoso, W. (2018). Revisiting (Non-) native influence in VOT production : insights from advanced L3 Spanish. *Languages*, *3*(3), 30. https://doi.org/10.3390/languages3030030

Llama, R., Cardoso, W., & Collins, L. (2010). The influence of language distance and language status on the acquisition of L3 phonology. *International Journal of Multilingualism*, *7*(1), 39–57. https://doi.org/10.1080/14790710902972255

Missaglia, F. (2010). The acquisition of L3 English vowels by infant German-Italian bilinguals. *International Journal of Multilingualism*, *7*(1), 58–74. https://doi.org/10.1080/14790710902972289

Onishi, H. (2016). The effects of L2 experience on L3 perception. *International Journal of Multilingualism*, *13*(4), 459–475. https://doi.org/10.1080/14790718.2016.1217604

Patience, M. (2018). Acquisition of the tap-trill contrast by L1 Mandarin–L2 English–L3 Spanish speakers. *Languages*, *3*(4), 42. https://doi.org/10.3390/languages3040042

Rothman, J., Hall, P., & Amaro, J. C. (2010). What variables condition syntactic transfer? A look at the L3 initial state. *Second Language Research*, *262*(September 2008), 189–218. https://doi.org/10.1177/0267658309349410

Sato, C. J. (1984). Phonological processes in second language acquisition: Another look at interlanguage syllable structure. *Language Learning*, *34*(4), 43–57. https://doi.org/10.1111/j.1467-1770.1984.tb00351.x

Setter, J. (2008). Consonant clusters in Hong Kong English. *World Englishes*, *27*(3), 502–515. https://doi.org/10.1111/j.1467-971X.2008.00581.x

Setter, J., & Deterding, D. (2003). *Extra final consonants in the English of Hong Kong and Singapore* (pp. 12–14).

Slabakova, R. (2017). The scalpel model of third language acquisition. *International Journal of Bilingualism*, *21*(6), 651–665. https://doi.org/10.1177/1367006916655413
Sypiańska, J. (2016). Multilingual acquisition of vowels in L1 Polish, L2 Danish and L3 English. *International Journal of Multilingualism*, *13*(4), 476–495. https://doi.org/10.1080/14790718.2016.1217606
Westergaard, M., & Rodina, Y. (2017). Crosslinguistic influence in the acquisition of a third language : The linguistic proximity model. *International Journal of Bilingualism*, *2*(6), 666–682. https://doi.org/10.1177/1367006916648859
Wrembel, M. (2010). L2-accented speech in L3 production. *International Journal of Multilingualism*, *7*(1), 75–90. https://doi.org/10.1080/14790710902972263
Wrembel, M. (2012). Foreign accentedness in third language acquisition: The case of L3 English. In J. C. Amaro, S. Flynn, & J. Rothman (Eds.), *Third language acquisition in adulthood* (pp. 281–309). John Benjamins Publishing Company.
Wrembel, M. (2015). Metaphonological awareness in multilinguals: A case of L3 Polish. *Language Awareness*, *24*(1), 60–83. https://doi.org/10.1080/09658416.2014.890209
Yip, V., & Matthews, S. (2011). *Cantonese: A comprehensive grammar* (2nd ed.). Routledge.

Appendices

Appendix A

Word list for consonant cluster production.

Akt, Allianz, ausbombt, bald, Bild, blau, bloβ, Blut, deshalb, doppeln, eins, elf, falls, fischt, flach, Fleiβ, Fluss, fremd, fünf, gefilmt, gelb, Geld, gequalmt, Gift, Glas, gleich, Glück, Gramms, greifst, Haft, halb, Hals, haltst, handeln, hängt, hübsch, Inseln, Kampf, klappen, klar, Kleid, knapp, Knie, Knochen, löscht, meistens, Mensch, mischt, mittels, Mund, oft, Pelz, Pfand, Pflaume, Pfleger, Pflicht, Pilz, Plan, plözlich, Plural, prompt, psychisch, Psychologie, Quadrat, Qualität, Quatsch, Residenz, rückt, rufst, Samt, schimpf, schlafen, schlimm, Schlüssel, schmal, schmecken, schmilzt, Schmuck, Schnee, Schneider, Schnitt, schwanger, schwarz, schwimmen, Sekt, Senf, Skandal, Skandinavien, Skelett, Spaß, Speise, Spiel, stehen, Stein, Steuer, stimmt, stolz, Stuhl, stumpf, Tanz, uns, Wolf, Wunsch, Wurms, zwar, zwei, zwischen, zwölf.

Appendix B

Participant information.

Participant	Age	Sex	TGC	YOL	GAC
S1	22	M		2 yr 6 mo	N
S2	20	M		3 yr	Y
S3	20	M		3 yr	Y
S4	21	M	1 mo	3 yr	Y
S5	22	F	1 mo	2 yr 6 mo	Y
S6	23	F		2 yr 6 mo	N
S7	22	F	1 mo	2 yr 6 mo	Y
S8	21	F	1 mo	2 yr 6 mo	N
S9	22	F	1 mo	2 yr 6 mo	N
S10	22	M		2 yr 6 mo	Y
S11	25	F	1 mo	2 yr 6 mo	N
S12	23	F	4 mo	2 yr 6 mo	Y
S13	25	M	6 mo	2 yr 6 mo	N
S14	22	F		2 yr 6 mo	N
S15	22	F		2 yr 6 mo	Y
S16	22	F	4 mo	1 yr 6 mo	Y
S17	22	F		1 yr 6 mo	Y

(*Continued*)

Continued.

Participant	Age	Sex	TGC	YOL	GAC
S18	22	F		1 yr 6 mo	Y
S19	23	M		1 yr 6 mo	Y
S20	21	F	0.5 mo	1 yr 6 mo	Y
S21	20	F	1 mo	1 yr 6 mo	N
S22	23	M	1 mo	1 yr 6 mo	N
S23	22	M	1 mo	1 yr 6 mo	Y
S24	22	F		1 yr 6 mo	N
S25	22	M		1 yr 6 mo	Y
S26	23	M	12 mo	1 yr 6 mo	Y

TGC = Time spent in a German-speaking country.
YOL = Year of learning German.
GAC = German usage after class.