What does the pronunciation of plosives and fricatives by Chinese learners of Portuguese teach us?

Adelina Castelo

Macao Polytechnic Institute (Portuguese Language Teaching and Research Centre)

& Centre of Linguistics of University of Lisbon

Taipa Campus, Macao Polytechnic Institute, Avenida Padre Tomás Pereira,

Taipa, Macau – China

00853 8399 8629

adelina.castelo@ipm.edu.mo

Author's biography

Adelina Castelo is an Associate Professor in Macao Polytechnic Institute (Macao SAR, China) since 2015, where she teaches courses of Portuguese Language, Language Laboratory and where she gives training sessions to teachers of Portuguese in mainland China. Prior to teaching in Macao, she earned her bachelor's degree in Modern Languages and Literatures - Portuguese and French Studies (1999), master's degree in Portuguese Linguistics (2004) and doctoral degree in Educational Linguistics (2012), all from University of Lisbon, and also taught Linguistics, Language Acquisition, Psycholinguistics, Mother Tongue Education and Portuguese as a Foreign Language in different colleges in Portugal.

Her areas of research encompass phonology, phonological awareness, teaching of oral skills and pronunciation, and she has collaborated in several research projects

at the Center of Linguistics of the University of Lisbon. Adelina Castelo has also presented several communications in academic meetings, as well as published papers and books, namely a series of materials to teach Portuguese pronunciation through songs (*Sons da fala e sons do canto: música para ensinar Fonética do Português. Volume 1: Música de Portugal* and *Volume 2: Música do Brasil*, 2017, Macao, MPI).

Abstract

Producing didactic materials for teaching the Portuguese pronunciation to Chinese learners should take into account their specific difficulties. Consequently, defining the phonetic-phonological profile of these learners is one of the important tasks to be accomplished, and for this purpose a study based on the oral production data of plosives and fricatives is still in need. The aim of the present study is: (i) to identify the problems faced by the Chinese learners of Portuguese in the pronunciation of plosives and fricatives; (ii) to draw the didactic implications for the teaching of pronunciation.

Eight native speakers of Mandarin Chinese were asked to name orally pictured objects. The words included in the corpus were controlled for some linguistic variables (e.g. stress position) and included one of the twelve obstruent consonants in standard European Portuguese. The results are analyzed in terms of (i) the impact of linguistic variables on the success rate and (ii) the reconstruction strategies for non-target productions. An important finding is the existence of significantly more difficulties with voiced plosives. Finally, the contributions to the definition of the phonetic-phonological profile of Chinese learners of Portuguese and to these consonants' pronunciation teaching are systematized.

Keywords: pronunciation teaching, learners' phonetic-phonological profile, Portuguese as Foreign Language, Chinese learners, production data, obstruent consonants

Resumo

A produção de materiais didáticos para ensinar a pronúncia portuguesa aos alunos chineses deve ter em conta as suas dificuldades específicas. Consequentemente,

a definição do perfil fonético-fonológico destes alunos é uma das tarefas importantes a serem realizadas e, para isso, ainda é necessário um estudo com base em dados de produção oral de oclusivas e fricativas. O objetivo do presente estudo é: (i) identificar as dificuldades dos estudantes chineses de português na pronúncia de oclusivas e fricativas; (ii) retirar dos resultados as implicações didáticas para o ensino da pronúncia.

Oito falantes nativos de chinês mandarim nomearam oralmente objetos a partir de imagens. As palavras do corpus foram controladas quanto a variáveis linguísticas (por exemplo, posição do acento) e incluíram uma das doze consoantes obstruintes do português europeu padrão. Analisam-se os resultados em termos de (i) o impacto das variáveis linguísticas sobre a taxa de sucesso e (ii) as estratégias de reconstrução para produções não conformes ao alvo. Uma descoberta importante é a existência de dificuldades significativamente maiores com as oclusivas vozeadas. Finalmente, sistematizam-se as contribuições para a definição do perfil fonético dos aprendentes chineses de português e para o ensino da pronúncia das consoantes.

Palavras-chave: ensino da pronúncia, perfil fonético-fonológico dos aprendentes, Português como Língua Estrangeira, aprendentes chineses, dados de produção, consoantes obstruintes

Introduction

The immense increase in the number of Chinese learners of Portuguese since 2005 is associated with several problems, namely the lack of: (i) didactic materials adjusted to them; (ii) experienced teachers to meet the demands; (iii) research on the profile and needs of this audience (see André, 2016). Defining the phonetic-phonological profile of these learners is one of the important research tasks that has to be developed. In fact, teaching pronunciation and creating didactic materials for this purpose should take into account the learners' specific problems in pronunciation, among several other principles. Although different parts of this task have already been addressed, a study based on the oral production data of plosives and fricatives is still necessary.

Considering the situation, the present study proposes to observe the acquisition of the oral plosives and fricatives of standard European Portuguese (EP) and has two goals: (i) to identify the difficulties faced by Mandarin Chinese (MC) speakers learning Portuguese as a Foreign Language (PFL) in the pronunciation of (oral) plosives and fricatives; (ii) to draw the didactic implications for the teaching of pronunciation to these learners.

According to the Second Language Acquisition literature, during the process of acquiring the L2 phonology[1], the learners develop an interphonology, i.e. a phonological system, simultaneously different from L1 and L2 (see concept of interlanguage by Selinker, 1972; Eckman, 2012), influenced by factors such as L1 properties, L2 properties and language universal principles. In this study I will focus only on the properties of L1 & L2.

[1] In this text, the expression L2 will be used to refer to all languages (being) acquired after the mother tongue (referred to as L1), as it is done, for instance, in Madeira (2017).

The means to study an interlanguage system include data of learners' (oral or written) production (e.g. Lakshmanan & Selinker, 2001; Zimmer & Alves, 2012), as well as data from comprehension tasks or grammaticality judgment tasks (e.g. Lakshmanan & Selinker, 2001). Besides those means, the teaching and learning experiences can also give us some insights into the typical interlanguage in a group of learners, although these experiences are normally not so valued because of their impressionistic basis. To achieve its goals, the present study will use oral production data, as these are a good means to analyze the linguistic knowledge, the interphonological mental representations of learners (e.g. Zimmer & Alves 2012).

In order to understand the difficulties faced by the MC native speakers learning the EP plosives and fricatives, it is important to briefly present both the target system and the one of mother tongue. Table 1 shows the (oral) plosives, fricatives and affricates at the underlying level of EP (Mateus & Andrade, 2000) and MC (Duanmu, 2007)[2], according to descriptions based on the autosegmental phonology (e.g. Clements & Hume, 1995). The two existing segments in each cell contrast in terms of voicedness (in the case of EP) and of aspiration (in MC).

Table 1

As it can be observed, at the EP underlying level there are six oral plosives: /p, b/ (two labial consonants, one voiceless and one voiced), /t, d/ (two anterior coronal consonants, also contrasting in voicedness), and /k, g/ (two dorsal consonants, voiceless and voiced). In MC, there are also six plosives. They present the same PoA of the Portuguese plosives, but they contrast in aspiration feature (instead of voicedness feature): /p, p^h/, /t, t^h/ and /k, k^h/.

[2] The phonological features of these consonants can be seen in Appendix 1.

Portuguese also has six underlying fricatives: /f, v/ (labial, contrasting in voicedness), /s, z/ (anterior coronal), /ʃ, ʒ/ (non-anterior coronal). In Chinese, for the /f, v/ Portuguese contrast there is only one phoneme, /f/; for the /s, z/ opposition there is only /s/; there are two non-anterior coronal consonants, but they are retroflex (instead of palatal, like in Portuguese) and contrast in aspiration /ʂ, ʂ^{h}/; finally there is a dorsal fricative /x/. Also, Chinese includes four phonological affricates (contrary to what occurs in Portuguese) that contrast in aspiration: the anterior coronal /ts, ts^{h}/; the non-anterior coronal /tʂ, tʂ^{h}/.

So, the plosive systems in the two languages present the same number of segments and the same PoA, the difference being that the Portuguese consonants contrast in voicedness while the Chinese ones contrast in aspiration. In terms of the fricative system, Chinese has again only contrast in aspiration, non-anterior coronal consonants that are retroflex (instead of palatal), and also includes four affricates.

It is also important to highlight that the voicedness in Chinese can present different values, but it does not have a phonological, contrastive value. While the phonetic realization of the underlying segments /p, t, k, ts, tʂ/ have a changing or irrelevant voicedness value, the segment /ʂ/ is predictably voiced and the aspirated consonants are predictably voiceless.

Besides describing the two phonological systems, the literature already provides us with some information about the acquisition of PFL by Chinese speakers. In fact, different authors have already highlighted some difficulties typical of these learners, which can be seen in Table 2.

Table 2

Even using different means, the various authors coincide greatly in the identified problems: they are associated especially with plosive consonants and voicedness feature. In addition to those problems, Yang (2017) also mentions difficulties with the perception of voicedness contrast in bilabial plosives and Wang (1991) refers to mistakes in the pronunciation of palatal fricatives.

Method

The participants were 8 native speakers of Mandarin Chinese, aged between 17 and 44, who had been studying Portuguese in Macau during 1 year. Seven were College students of a bachelor degree related to Portuguese; one was a teacher of English who was studying Portuguese in a language school and also attending some classes of the same bachelor degree program.

In order to elicit the oral productions, a corpus of three words per consonant was created. As much as possible, the words used as stimuli presented CV syllables and were stressed on the penultimate syllable, as these are the most frequent patterns in EP (Andrade & Viana, 1993; Vigário & Falé, 1993, on the syllable structure; Mateus & Andrade, 2000, on the stress pattern). The words were also expected to belong to the vocabulary of elementary learners and were easy to present through an image. Also, a balance was sought in terms of position (initial or medial) and stress (stressed or unstressed) of the syllables with the target consonant. The whole corpus is included in the Appendix 2 and Figure 1 shows the pictures used to elicit some of the words.

Figure 1

After the creation of the corpus, several procedures were adopted. First, the pictures were selected and tested with Chinese speakers different from the participants,

to make sure the participants, from the Chinese cultural background, would recognize the object and name the correct word. With the final selection of pictures a *PowerPoint* presentation was prepared. Then, volunteer participants were recruited in two classes and a schedule for the data collection was arranged. The data were collected in a quiet classroom by the author in a different session for each participant. After giving his/her informed consent and some information necessary to know his/her language background, each participant performed individually the task of orally naming the pictures presented in the *PowerPoint*. The oral productions were recorded in the software *Wavesurfer* (version 1.8.8p4) in .wav files, with 22050 Hz of sampling frequency, 16 bit, mono channel, through the microphone *Edifier* K815, with a frequency response of 20Hz-20KHz.

Later, the oral productions were phonetically transcribed by an experienced researcher and the data were codified in a database created in the software *SPSS* (*Statistical Package for Social Sciences*). Then, descriptive statistics were calculated and non-parametric tests were performed. During the results' analysis, the phonological development scale used by Costa (2010) was adopted: whenever the success rate in producing a consonant was below 50%, the consonant was considered non-acquired; for success rates between 50% and 79% the consonant was regarded as under the process of acquisition; if the success rates were above 79%, the consonant was seen as acquired.

Results

The results are analyzed in terms of: (i) the impact of linguistic variables (place of articulation, PoA; manner of articulation, MoA; voicedness; individual consonant) on the success rate; (ii) the reconstruction strategies in non-target productions (first,

plosives; then, fricatives).

In Table 3, we can see the success rates for the different places of articulation.

Table 3

The participants have 77% of success in producing the labial consonant according to the target, 68% in the anterior coronal consonant, 72% in the non-anterior coronal consonant, and 66% in the pronunciation of the dorsal one. These success rates do not differ much from each other and, as expected, no statistically significant difference is found (*Related-Samples Friedman's Two-Way Analysis of Variance by Ranks*, *p*=.457).

In Table 4, the success rates for the different manners of articulation are presented.

Table 4

There is only 59% of success in producing the plosives, and 85% in the pronunciation of fricatives. This difference reaches statistical significance (*Related-Samples Wilcoxon Signed Rank Test*, *p*=.017) and shows an impact of the MoA in the number of target-like productions.

Table 5 presents the success rates according to the variable voicedness.

Table 5

96% of the voiceless consonants are target-like productions, while the success rate for voiced consonants is only 50%. This difference is statistically significant (*Related-Samples Wilcoxon Signed Rank Test*, *p*=.012), showing that the linguistic variable voicedness has an impact on the performance level in the production of plosives and fricatives.

Table 6 and the graph in Figure 2 show the success rates for each consonant.

Table 6

Figure 2

The voiceless plosives and fricatives as well as the voiced fricative [v] (in green, in the graph) present success rates higher than 80%, which means that these segments have already been acquired. 77% of the productions for the voiced fricative [z] (in orange) are target-like, which shows that these consonant is under the process of acquisition. Finally, the performance level for the production of the voiced plosives and the voiced fricative [ʒ] (in red) ranges between 14% and 45%, which means that these sound structures are not acquired yet.

The reconstruction strategies in non-target productions are also important to understand the pronunciation difficulties faced by the Chinese learners of PFL. Table 7 shows the reconstruction strategies used for plosives, which always consisted of replacements of the target consonant by another one.

Table 7

When the learners do not produce the voiceless plosives according to the target, the replacing segments show aspiration (in 4 cases) or voicing instability (1 case). For instance, the target [p] was replaced by the aspirated counterpart in 2 responses and by a [b] consonant with some devoicing [3] in 1 response. As far as the voiced plosives are concerned, when the learners cannot produce them according to the target, they adopt the strategies of devoicing (used very often, in [p], [b̥], [t] [d̥], [k], [g̊], 44 cases)

[3] It is worth remembering that a voiced consonant transcribed with a small dot below or above indicates that the consonant loses its voicing in part or in all of its duration.

or aspiration (2 cases, [p^h] and [t^h]).

In Table 8 we can observe the reconstruction strategies for fricatives. Again, they are always replacements of the target consonant by another one.

Table 8

For the voiceless fricatives, there are no reconstruction strategies, since all consonants are produced target-like. As for the voiced fricatives, the reconstruction strategies always correspond to a replacement by another consonant and that replacement most often shows devoicing (11 cases, including [f], [s], [ʃ] and [d͡ʒ]) or affrication (8 cases, including [dz], [d͡ʒ] and [dʒ]). For instance, instead of [ʒ], there are 7 productions of [ʃ] (the voiceless counterpart) and 4 productions of [dʒ] or [d͡ʒ] (the corresponding affricate, in the voiced and the voiceless versions).

Discussion

The results do not show a specific impact of the linguistic variable PoA alone (i.e. Labial vs. Coronal [+ anterior] vs. Coronal [- anterior] vs. Dorsal) on the production of oral plosives and fricatives. The success rates in the different PoA range between 66% and 77% (Table 3), and these differences are statistically non significant. This agrees only partially with the literature on the PFL by Chinese learners: there are no references to problems associated with PoA alone in the pronunciation level (see section 1); only Yang (2017) finds an impact of PoA in the discrimination of voicedness in pairs of plosives, and Wang (1991) mentions some difficulties with palatal fricatives. The lack of an independent PoA effect in the production of plosives and fricatives is possibly motivated by the fact that L1 and L2 essentially use the

same phonological features to contrast PoA – more specifically, the nodes Labial vs. Coronal (with the feature [anterior]) vs. Dorsal – and the effect found by Yang (2017) may be due to an interaction with the feature voicedness.

By contrast, the results show clear and statistically significant differences in success rates of segments' production according to their MoA (i.e. plosive vs. fricative; Table 4) and voicedness (Table 5). In fact, almost all problems occur when the target segment is a voiced consonant (Table 6).

The voiced plosives present the lowest success rates (14%-41%, in Table 6), not having yet being acquired. The difficulties found in these segments agree with the many references in the literature to problems with plosives and voicedness (e.g. Nunes, 2015; Wang, 1991; Yang, Rato, & Flores, 2015). The reconstruction strategies used for these segments are mainly devoicing but also aspiration. These results are probably due to the absence of voicedness contrast and underlying voiced segments in L1. As MC phonological system does not include the phonemes /b, d, g/ or the voicedness contrast, the voiced plosives are very difficult to acquire by the Chinese learner, who instead tends to replace the target consonants by unvoiced or even aspirated consonants.

As for the voiced fricatives, their success rates are not as low as the ones of plosives, but there are some difficulties especially with the coronal ones ([z] and [ʒ]). While [v] is already acquired at this learning stage, [z] is under the process of acquisition and [ʒ] is not acquired (Table 6). The main reconstruction strategy used is again devoicing, and some of these fricative consonants are also replaced by affricate ones. These results can also be attributed to the absence of the voicedness contrast and the underlying segments /v, z, ʒ/ in L1. Besides, the lower success rates in coronal

segments [z] and [ʒ] and the affrication replacing them can be motivated by the availability in L1 of affricates with these places of articulation (coronal anterior [ts, ts^h]; coronal non-anterior [t̪s̪, t̪s̪^{h}]). These findings agree with the literature only partially: on the one hand, literature refers to problems with the voicedness contrast and the coronal non-anterior fricatives (as the ones found in this study); but, on the other hand, the previous authors do not mention problems with fricatives such as [z] and some results even suggest the labial plosives should be more difficult to discriminate than the coronal and dorsal ones (Yang, 2017).

Consequently, almost all problems seem to be related to the linguistic variable voicedness, which agrees with the many references to it found in the literature (e.g. Castelo et al., 2017; Wang, 1991; Xu, 2012; Yang et al., 2015). In terms of reconstruction strategies, devoicing is the most frequently used one for all consonants; and aspiration is also sometimes used for plosives, while affrication is adopted for fricatives. Possibly there is a redeployment of L1 features to try to solve the problem of non-activation of the voicedness phonological feature in Chinese. This redeployment, as proposed by Archibald (2006), depends on the phonological features active in L1 and the salience of phonetic/acoustic cues. In the present case, it is possible that the use of aspiration or affrication shows a tentative distinction between two classes of segments (the voiceless ones and the others, which are aspirated or affricated). The production of non-target-like segments may reveal a tentative and yet unsuccessful redeployment. In fact, as pointed out in Flege's *Speech Learning Model* (1995), in the case of a sound existent only in the target language, its discrimination and the formation of a different mental representation for it is more difficult if the closest sound in L1 is very similar to the sound to be acquired in L2. So, possibly the

distinction voiceless/voiced (not used contrastively in MC, but phonetically associated to the aspirated/unaspirated phonological contrast) is phonetically so close to the distinction aspirated/unaspirated (this last one used contrastively in MC) for a Chinese learner that its discrimination, mental representation and production are hindered and delayed.

Another finding from this study is the impact of the MoA on the learners' production performance: the results for the fricative voiced consonants are better than those for the plosive ones. This asymmetry can be caused by the longer duration of the fricatives (e.g. Murphy, Pagan-Neves, Schochat, & Wertzner, 2009; Pape & Jesus, 2015): being longer than the plosives, the fricatives become acoustically more salient, allow the learner to be more aware of their voiced value and, consequently, to acquire their properties fully. As proposed by Archibald (2006), the salience of the phonetic cues is also important to facilitate the redeployment. In this case, the salience of fricative phonetic cues (compared to the plosive ones) would explain the faster acquisition of voicedness contrast for the fricative consonants (than for the plosive ones).

Finally, as far as the PoA is concerned, the results suggest there is no independent impact of the PoA on the production of plosives and fricatives, but there might be an effect of PoA associated with the voicedness and MoA variables, which accounts for the following facts: (i) more difficulties with the production of coronal voiced fricatives than with the labial ones have been found in this study; (ii) a previous study found the effect of PoA in the discrimination of pairs of plosives contrasting in voicedness (Yang, 2017). Consequently, the impact of the PoA in the production and perception of plosives and fricatives deserves further research.

Considering the reported findings, the phonetic-phonological profile of Chinese

learners of PFL after one year of learning can be summarized as: (i) presenting non-target-like segments especially for voiced plosives and coronal voiced fricatives (voiced plosives and [ʒ] are non acquired; [z] is in the process of being acquired; voiceless plosives and fricatives, as well as voiced [v] are already acquired); (ii) showing a tentative and unsuccessful redeployment of other phonological features (i.e. aspiration, affrication) to deal with voiced consonants, as a consequence of the inexistence of voicedness contrast in L1.

From this profile of Chinese learners we can learn two important things. The first didactic implication to be drawn from it is the need to address directly and explicitly the voicedness feature, by promoting voicedness contrast and dissociating it from the aspiration feature (with no role in the Portuguese phonology). This can be done in very different ways, such explicitly teaching, from the very beginning, that: the MC [p, t, k] (in *pinyin*[4], <b, d, g>) correspond to the EP [p, t, k] <p, t, c/qu/k>; the MC [p^h, t^h, k^h] (in *pinyin* <p, t, k>) have no corresponding sounds in EP; no sounds in MC correspond to the EP [b, d, g] <b, d, g/gu>, which thus have to be acquired as new phonetic categories. Also, minimal pairs (examples: *moda*, fashion, vs. *mota*, motorcycle; *gama*, gamut, vs. *cama*, bed) can be used to practice the discrimination of the voicedness contrast. In addition, it is possible to use spectrograms to help students visualize the phonetic difference they tend to categorize in the same way: aspiration has some acoustic properties while voicedness presents other properties.

The second didactic implication from these results is the recommendation to "increase" the robustness, the salience of the phonetic cues while promoting the development of the new phonetic-phonological categories. Since the salience of the

[4] *Pinyin* is the official Romanization system for Standard Chinese used in the People's Republic of China.

phonetic cues help in the redeployment of L1 properties to acquire new L2 properties (as it is shown by the superior performance with fricatives compared to plosives), it is crucial to direct learners' attention to these phonetic cues and to intensify them when modeling production. In order to do that, it is possible, for instance, to use again oral discrimination tasks (with minimal pairs) or modeled sound production (with the pronunciation and contrast of isolated sounds, as well as showing how aspiration and voicedness are produced).

Final remarks

Learning a foreign language frequently involves creating new categories, based on the linguistic knowledge of the new target language, as well as of the mother tongue. In order to gain a better understanding of this process and of the difficulties faced by the learners, it is crucial to observe empirical data of a specific learning stage, by taking into account the L2 and the L1 systems involved in the process. This better understanding of the process can then allow us to identify specific didactic implications which are useful when developing the didactic strategies and materials to use in the classroom.

In this study, the oral productions of (oral) plosives and fricatives by Chinese Mandarin speakers having learned PFL for one year were analyzed. The results showed us difficulties especially in voiced plosives and coronal voiced fricatives, revealing a specific problem with voicedness, which can be related to the absence of voicedness contrast in MC phonology. Besides, the problem is more acute when voicedness and plosive MoA are combined, which can be accounted for by some less salient phonetic cues of plosives (as compared to fricatives). These results allowed us to identify the phonetic-phonological profile of these learners at this learning stage

(difficulties especially with voiced plosives and coronal voiced fricatives; tentative redeployment of aspiration and affrication to deal with the voicedness contrast, absent in L1) and also to draw two didactic implications (direct and explicit teaching of voicedness as distinct from aspiration; intensification of phonetic cues of the new, voiced, categories to be acquired).

Although these results are already helpful to have a better understanding of the process and the way to facilitate it, many tasks and questions are left for further research. Some of these should be highlighted. In the first place, it is crucial to increase the number of participants, in order to make more secure generalizations about Chinese learners at this learning stage. Second, it is necessary to investigate possible other causes for the identified difficulties, namely the possible impact of the PoA variable in the performance on pronunciation of plosives and fricatives. Finally, the efficacy of the presented didactic implications should be tested with training studies.

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Table 1: The (oral) plosives, fricatives and affricates at the underlying level of EP (L2, target language; Mateus & Andrade, 2000) and MC (L1; Duanmu, 2007)

		PoA (Place of Articulation)						**Language**
		Labial		**Coronal**			**Dorsal**	
				[+ ant]	**[- ant]**			
		Bilabial	**Labiodental**	**Dental**[5]	**Palatal**	**Retroflex**	**Velar**	
MoA (Manner of Articulation)	**Plosives**	p b		t d			k g	EP
		p p^h		t t^h			k k^h	MC
	Fricatives		f v	s z	ʃ ʒ			EP
			f	s		ʂ $ʂ^h$	x	MC
	Affricates							EP
				ts ts^h		tʂ $tʂ^h$		MC

[5] Although [t, d, s, z] are sometimes also considered alveolar and [ʃ, ʒ] are classified as postalveolar, in the descriptions of EP they are generally classified as dental and palatal, respectively (e.g. Mateus & Andrade, 2000).

Table 2: Problems identified in the plosive and fricative systems of Chinese learners of PFL by different authors

Problems	**Means**	**Authors**
Plosives – voiced / unvoiced contrast	Written production data	Nunes, 2015
Plosives – especially voiced / unvoiced contrast	Oral perception data	Yang, Rato, and Flores, 2015
Plosives & voiced / unvoiced contrast – especially bilabial consonants	Oral perception data	Yang, 2017
Voiced / unvoiced contrast – especially plosives & palatal fricatives	Teaching experience	Wang, 1991
Voiced / unvoiced contrast	Teaching experience	Xu, 2012
Voiced / unvoiced contrast	Survey on teaching experiences	Castelo et al., 2017

Table 3: Success rates for PoA

	Target-like productions	
	count	**%**
Labial	66	77%
Coronal [+ anterior]	53	68%
Coronal [- anterior]	28	72%
Dorsal	25	66%

Table 4: Success rates for MoA

	Target-like productions	
	count	**%**
Plosive	73	59%
Fricative	99	85%

Table 5: Success rates for voicedness

	Target-like productions	
	count	**%**
Voiceless	108	96%
Voiced	64	50%

Table 6: Success rates for each individual consonant

Labial			**Coronal**						**Dorsal**		
			[+ant]			**[-ant]**					
	count	**%**		**count**	**%**		**count**	**%**		**count**	**%**
[p]	16	84%	[t]	20	91%				[k]	16	100%
[b]	7	32%	[d]	3	14%				[g]	9	41%
[f]	24	100%	[s]	13	100%	[ʃ]	19	100%			
[v]	19	90%	[z]	17	77%	[ʒ]	9	45%			

Table 7: Reconstruction strategies (replacements) for plosives

Labial			**Coronal**						**Dorsal**		
			[+ant]			**[-ant]**					
target	**actual production**		**target**	**actual production**		**target**	**actual production**		**target**	**actual production**	
[p]	[pʰ]	2	[t]	[tʰ]	2				[k]		
	[b̥]	1									
[b]	[p]	8	[d]	[t]	12				[g]	[k]	10
	[b̥]	6		[d̥]	5					[g̊]	3
	[pʰ]	1		[tʰ]	1						

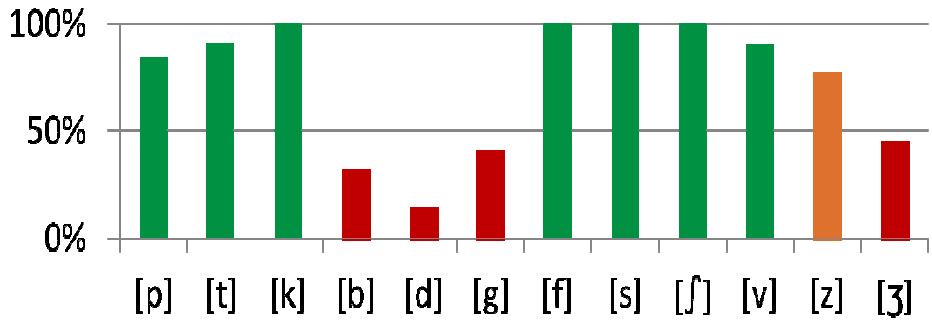
Table 8: Reconstruction strategies (replacements) for fricatives

Labial			**Coronal**						**Dorsal**		
			[+ant]			**[-ant]**					
target	**real production**		**target**	**real production**		**target**	**real production**		**target**	**real production**	
[f]			[s]			[ʃ]					
[v]	[f]	1	[z]	[ʣ]	4	[ʒ]	[ʃ]	7			
	[ʊ]	1		[s]	1		[ʤ]	2			
							[ʤ]	2			

Figure 1: Pictures used to elicit some of the words

 *sapato*, shoe	 *gelado*, icecream	 *gato*, cat

Figure 2: Success rates for each individual consonant



Appendices

Appendix 1: Phonological features of plosives, fricatives and affricates in EP and MC

The proposed systematization is a combination of the descriptions by Mateus & Andrade (2000) for EP and Duanmu (2007) for MC. For EP the authors only use the feature [continuant] to differentiate plosives from all other consonants, while in MC the features [stop], [fricative] and [aspirated] are also needed.

European Portuguese (EP) **(Mateus & Andrade, 2000)**							***Mandarin Chinese (MC)*** **(Duanmu, 2007)**					
p	**b**	**t**	**d**	**k**	**g**		**p**	**p^h**	**t**	**t^h**	**k**	**k^h**
–	+	–	+	–	+	**[voice]**		**(-)**		**(-)**		**(-)**
						[aspirated]	–	+	–	+	–	+
						MoA						
+	+	+	+	+	+	**[stop]**	+	+	+	+	+	+
						PoA						
•	•					**Labial**	•	•				

		•	•			**Coronal**			•	•		
		+	+			**[anterior]**			+	+		
				•	•	**Dorsal**					•	•

EP **(Mateus & Andrade, 2000)**							***MC*** **(Duanmu, 2007)**								
f	**v**	**s**	**z**	**ʃ**	**ʒ**		**f**	**s**	**ʂ**	**ʂ^{h}**	**x**	**ts**	**ts^{h}**	**tʂ**	**tʂ^{h}**
–	+	–	+	–	+	**[voice]**	**(-)**	**(-)**	**(+)**	**(-)**	**(-)**		**(-)**		**(-)**
						[asp]	–	–	–	+	–	–	+	–	+
						MoA									
–	–	–	–	–	–	**[stop]**	–	–	–	–	–	+	+	+	+
+	+	+	+	+	+	**[fric]**	+	+	+	+	+	+	+	+	+
						PoA									
•	•					**Labial**	•								
		•	•	•	•	**Coronal**		•	•	•		•	•	•	•
		+	+	–	–	**[ant]**		+	–	–		+	+	–	–
						Dorsal					•				

Appendix 2: List of stimuli

[p] *so**p**a*, soup *sa**p**ato*, shoe *sa**p**atinho*, little shoe	**[t]** *se**t**e*, seven *cas**t**elo*, castle *cas**t**elinho*, little castle	**[k]** *bo**c**a*, mouth *pes**c**oço*, neck *pes**c**ocinho*, little neck
[b] ***b**olo*, cake *ca**b**elo*, hair *ca**b**elinho*, little hair	**[d]** *bigo**d**e*, mustache ***d**edo*, finger ***d**edinho*, little finger	**[g]** ***g**ato*, cat *bi**g**ode*, mustache *bi**g**odinho*, little mustache
[f] ***f**ruta*, fruit *ele**f**ante*, elephant *ele**f**antinho*, little elephant	**[s]** ***s**apato*, shoe *pesco**ç**o*, neck *pesco**c**inho*, little neck	**[ʃ]** ***ch**uva*, rain *mo**ch**ila*, backpack *mo**ch**ilinha*, little backpack
[v] *no**v**e*, nine *re**v**ista*, magazine *re**v**istinha*, little magazine	**[z]** *me**s**a*, table *cami**s**ola*, sweater *cami**s**olinha*, little sweater	**[ʒ]** ***g**elado*, icecream ***j**anela*, window ***j**anelinha*, little window