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Orthographic input and phonological representations in learners of Chinese as a Foreign Language
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Abstract

This paper provides evidence that the second language orthographic input affects the mental representations of L2 phonology in instructed beginner L2 learners. Previous research has shown that orthographic representations affect monolinguals' performance in phonological awareness tasks; in instructed L2 learners such representations could also affect pronunciation. This study looked at the phonological representations of Chinese rimes in beginner learners of Chinese as a Foreign Language, using a phoneme counting task and a phoneme segmentation task. Results show that learners do not count or segment the main vowel in those syllables where it is not represented in the pinyin (romanisation) orthographic representations. It appears that the pinyin orthographic input is reinterpreted according to L1 phonology-orthography correspondences, and interacts with the phonological input in shaping the phonological representations of Chinese syllables in beginner learners. This explains previous findings that learners of Chinese do not pronounce the main vowel in these syllables.

INTRODUCTION

The role of the orthographic input in the acquisition of second language phonology has been hitherto almost completely neglected. On the one hand, research on monolingual speakers shows that their performance in phonological awareness tasks is affected by orthographic representations. On the other hand, research on second language (L2) learners shows that their L2 pronunciation is affected by L2 orthographic representations. Do L2 orthographic representations affect the mental representations of L2 phonology in L2 learners, such leading to non-target-like pronunciations? This paper looks at the effects of some orthographic conventions of the pinyin romanization system on the phonological representations of Chinese syllables in instructed beginner learners of Chinese as a Foreign Language (CFL). It is proposed that the non-target-like pronunciation of some syllables by CFL learners can be attributed to the effects of the pinyin orthographic representations on learners' L2 phonological representations.

Effects of orthography on L1 phonological representations

Much research shows that the phonological awareness of literate speakers, as reflected in phonological awareness tasks, is affected by the orthographic representation of the spoken language at both a global and local level. At a global level, writing systems largely determine which language units literate speakers are aware of, i.e. which language units they can identify (as reflected in counting, segmenting or matching tasks) and manipulate (as reflected in moving, deleting, adding, reversing or blending tasks). At a local level, the specific orthographic form of a language unit (e.g., a word or a syllable) can affect how literate speakers represent its phonology.

At the global level, readers of alphabetic writing systems are aware of phonemes, literate Japanese speakers are aware of morae, literate Arabic speakers are aware of CV units, and so on (Cook and Bassetti 2005). Speakers are generally not aware of language units not represented in their writing system: illiterates mostly cannot perform tasks requiring awareness of phonemes (Bertelson et al. 1989; Morais et al. 1979); literate English speakers cannot consistently identify syllable boundaries (Miller et al. in preparation). Native speakers of a same language can or cannot identify and manipulate language units depending on which writing system they know (Padakannaya 2000; Read et al. 1987), and even minimal exposure to a writing system can improve performance on tasks requiring awareness of the language units it represents (Huang & Hanley 1997; Ko & Lee 1997). When requested to manipulate language units not represented in

their writing system, speakers can adopt complex strategies involving the manipulation of the phonological units represented in their writing system (Mann 1986). It appears that different types of writing systems (alphabetic, consonantal, etc.) provide different models for the analysis of language, segmenting language in different units and making these units apparent to their readers.

At the local level, native speakers' phonological representations of a specific language unit can be affected by its orthographic form. For instance, word spellings affect performance in phoneme identification and manipulation tasks. Literate English speakers count more phonemes in a word spelled with more letters (e.g. <debt> vs. <dot>) (Derwing 1992; Perin 1983); and count two-phoneme strings as single phonemes if they correspond to letter names (e.g., [ai] is one phoneme because it corresponds to <i>) (Treiman & Cassar 1997). In phoneme manipulation tasks, English speakers have more difficulty manipulating phonemes that are not present in a word's orthographic representation, as in deleting [k] from 'fixed' (Castles et al. 2003; Scholes & Willis 1991). At the suprasegmental level, literate speakers are faster at deciding whether two words rhyme if the rimes have similar spellings (e.g., toast-roast vs. toast-ghost) and if the rimes have only one possible spelling rather than multiple spellings (Seidenberg & Tanenhaus 1979; Ventura et al. 2004). The effects of literacy on phonological awareness are evident when preliterate and literate children are compared: after the onset of literacy, children start counting more phonemes and more syllables in words spelled with more letters (<pitch> vs. <rich>; <interesting> segmented as 'in-ter-es-ting' rather than 'in-tres-ting') (Ehri & Wilce 1980); children also only start considering nasals as phonemes after learning that nasals are represented as letters in writing (Treiman et al. 1995).

It appears that orthographic representations affect native speakers' performance in phonological awareness tasks, and even their performance in speech production experiments involving oral priming (e.g., Damian and Bowers 2003). Still, orthographic representations clearly do not affect native speakers' pronunciation (with the possible exception of a few spelling pronunciations, e.g. Italian [tʃiɛlo] for <cielo> ≡ [tʃɛlo]). On the other side, instructed second language learners are exposed to orthographic representations without mastering the L2 phonology, and much of the input they receive is written rather than spoken. It is therefore possible that the orthographic representations of the second language, besides affecting performance in phonological awareness tasks, could affect L2 pronunciation as well.

Effects of orthography on L2 phonology

Previous research has shown the effects of writing systems on second language phonological representations. At a global level, both the writing systems known by an L2 learner determine which language units s/he can identify and manipulate in the second language. For instance, English learners of L2 Hebrew can delete phonemes from Hebrew words faster than native speaker-readers of (consonantal) Hebrew (Ben-Dror et al. 1995); Russian learners of English as a Second Language (ESL) outperform Japanese learners in phoneme deletion (Wade-Woolley 1999); English learners of Chinese reach higher agreement rates on Chinese word boundaries than native speaker-readers of (morphemic) Chinese (Bassetti 2005); Kannada speakers literate in English perform Kannada phonemic awareness tasks better than monolingual speaker-readers of (syllabic) Kannada (Padakannaya et al. 1993). The writing system used to represent one language (L1 or L2) provides a model of linguistic analysis which bilinguals can then apply to analyse their other language (L2 or L1). Furthermore, the effects of writing systems are also visible at the level of the single language unit.

At this local level, the specific orthographic representations of second language units (phonemes, words, etc.) affect learners' second language production, in both L2 spelling and pronunciation. For instance, some spelling errors in Japanese ESL learners are caused by the use of the L1 Japanese transcription system *romaji* to represent the pronunciation of L2 English words (Okada 2005). The L2 orthographic input affects L2 pronunciation at both the segmental

and suprasegmental level, as shown in various studies by Young-Scholten and her colleagues (see Young-Scholten 2002). For instance, although the phonological input shows that German obstruents are devoiced in word final position, English learners of L2 German realize word-final obstruents as voiced, because they are spelled as voiced obstruents, e.g. pronouncing [d] instead of [t] in <Bund> (Young-Scholten 2002). At the suprasegmental level, while Polish long consonant clusters are difficult to pronounce for children and L2 learners alike, Polish children solve the problem by deleting consonants, whereas L2 learners add epenthesis; Young-Scholten argued that this is due to the L2 learners' exposure to the orthographic input, which leads them to retain all the consonants they see in the written word (Young-Scholten 1998). Furthermore, L2 learners use epenthesis when orthographic input is provided along with phonological input, but when only phonological input is provided they use consonant deletion (Young-Scholten et al. 1999).

All these studies show that the L2 orthographic input affects L2 production (spelling and pronunciation). The orthographic input results in non-target-like pronunciations that cannot be explained in terms of L1 influence or L2 phonological input, and to differences between the early phonologies of children and L2 learners. The most likely explanation is that the orthographic input is interfering with the phonological input in the creation of L2 learners' mental representations of the L2 phonology, at both the segmental and suprasegmental level.

Chinese phonology and pinyin orthography

Standard Chinese (also 'putonghua' or 'Mandarin', from now on 'Chinese') has about 400 syllabic types. The syllable structure is simple: the onset can contain only one (optional) consonant, and the coda can contain only one of 2 nasals (optional): $C_{(0-1)}V N_{(0-1)}$. The nucleus must contain at least one vowel (with tone), and it consists of one of 7 simple vowels, 9 diphthongs or 4 triphthongs.

Hanyu pinyin ('Chinese phonetic transcription system') is the official romanization system in the People's Republic of China, and the international standard transcription system for Chinese (International Organization for Standardization, 1991). It is a phonologically transparent orthography with one-to-one grapheme-phoneme correspondences (e.g., <ma> ≡ [ma], <mang> ≡ [maŋ]). When pinyin was created, it was for some time meant to be used as a writing system to replace *hanzi*, the Chinese characters (Chen 1999). For this reason, it has some orthographic conventions that were meant to facilitate reading and writing, such as spelling syllable-initial [i] as <y> to mark syllable boundaries (e.g., [ian] ≡ <yan> vs. [ni ɛ n] ≡ <nian>, to distinguish [fan·ian] ≡ <fanyan> from [fa·ni ɛ n] ≡ <fanian>).

The present study focusses on three Chinese rimes, [uei], [iou] and [uən], whose phonological and orthographic forms will be introduced here. Chinese diphthongs and triphthongs are composed of a main vowel, preceded and/or followed by a high vowel ([i], [u], [y])[1] (e.g., [ye], [ei], [iɑu], [iou]). In triphthongs the main vowel is always the central one, in diphthongs it can be the first or the second; a high vowel cannot be the main vowel in diphthongs and triphthongs. The main vowel has the most intensity and is the longest, with length ratios of 6:4 for ongliding diphthongs, 4:6 for offgliding ones and 4:4:2 for triphthongs (Cao & Yang 1984). According to some researchers, the main vowel in the three rimes [iou] [uei] and [uən] changes depending on the tone: it has more intensity and length in the third and fourth tones than in the first and second tones (Norman 1988).

In pinyin orthography, these three rimes are spelled differently in different contexts: in post-consonantal position, the main vowel is not represented, i.e. [uei] ≡ <ui> (vs. <wei> in syllables with no consonantal onset). When the main vowel is not represented, the tone marker, which is normally placed on the main vowel, is placed on the last vowel, e.g. <duì> vs. <wèi>. Table 1 presents the two alternative spellings for these three rimes, with a consonantal onset (C__) and without it (#__); in post-consonantal contexts, (C__ column) one vowel is clearly not

represented in pinyin transcriptions. The table also lists the syllabic types containing each rime, both with and without consonantal onset.

Rime	Pinyin spelling		Number of syllables
	C__	**#__**	
uei	ui	wei	12 (chui, cui, dui, gui, hui, kui, rui, shui, sui, tui, zhui, zui) + wei
iou	iu	you	7 (diu, jiu, liu, miu, niu, qiu, xiu) + you
uən	un	wen	13 (chun, cun, dun, gun, hun, kun, lun, run, shun, sun, tun, zhun, zun) + wen

Table 1.   Pinyin spelling of three rimes in syllables with and without consonantal onset (C__   and #__   respectively). The   C__   column lists orthography-phonology inconsistent spellings.

Not all Chinese transcription systems adopt these orthographic conventions. Both the phonetic transcription systems used in Taiwan (*tongyong pinyin* and *zhuyin fuhao*) represent these rimes with the same number of graphemes regardless of the environment; Wade-Giles, a romanization system which was widely used in the past, omits the main vowel in [iou] and [uən] but not in [uei]. Nonetheless, nowadays pinyin is the most widely used transcription system in the teaching of L2 Chinese. If L2 orthographic representations affect L2 learners' phonology, learners of L2 Chinese should be affected by the orthographic conventions described above.

1.4 Effects of pinyin orthographic conventions on L2 phonology

Researchers found various effects of pinyin on second language pronunciation in Chinese language learners. For instance, pinyin represents the aspirated/unaspirated contrast using the letters used in English to represent the voiced/unvoiced contrast, e.g. using <b> for [p] and <p> for [pʰ]. This is useful from the point of view of a writing system, as it eliminates the need for special symbols such as apostrophes to distinguish aspirated consonants (used for instance in Wade-Giles). On the other hand, researchers found that English learners of Chinese pronounce the Chinese aspirated/unaspirated contrast as a voiceless/voiced contrast because of their pinyin representation (Meng 1998).

Effects of pinyin were also found at the suprasegmental level. Researchers found that L2 learners of Chinese reduce the three rimes [iou], [uei] and [uən]: for instance, they pronounce [tuei] as [tui], [tiou] as [tiu] and [tuən] as [tun], in line with their pinyin spellings <dui>, <diu> and <dun> (Ye et al.1997). In a more recent paper, Bassetti (forthcoming) found that Italian final-year university students of Chinese never deleted vowels in syllables containing the triphthongs [iau], [uai] and [uan], which are consistently spelled in pinyin. The researcher also compared the pronunciation of the three rimes [iou], [uei] and [uən] in orthography-phonology consistent and inconsistent syllables. She found that no vowels were deleted in syllables whose pinyin transcription represented all vowels, but vowels were often deleted in the same rimes in orthography-phonology inconsistent syllables. The L2 learners' non-target-like pronunciations cannot be explained as a consequence of phonological input, as the omitted vowel is the main vowel, i.e. the loudest and longest in the rime. Such pronunciations cannot be due to the influence of L1 phonology either, because learners can produce these rimes in syllables with no consonantal onset, i.e. they can produce [iou] but reduce [tiou] to [tiu].

The present study investigates whether the non-target-like pronunciations of these rimes could be due to the effects of pinyin orthography on the mental representations of Chinese syllables in L2 learners. The only way the orthographic input can affect L2 pronunciation is by interfering with the phonological input in establishing L2 learners' phonological representations. If phonological awareness tasks reveal that L2 learners' mental representations do not include the main vowel, that would explain why this vowel is not produced in L2 pronunciation.

It was therefore decided to use two phonological awareness tasks to tap into CFL learners' mental representations of Chinese rimes. In the *phoneme counting task*, English learners of

Chinese as a Foreign Language (CFL) were asked to count phonemes in syllables. The same rime was presented in syllables whose pinyin spelling does not represent the main vowel (e.g., <dui> ≡ [duei]) and in syllables whose pinyin spelling represents the main vowel (e.g., <wei> ≡ [uei]). The hypothesis was that English CFL learners would count one less vowel in syllables whose spelling does not contain the main vowel, showing that their mental representations of these syllables does not include the main vowel. In the *phoneme segmentation task*, CFL learners were asked to pronounce all phonemes in syllables one by one. Again, the same rime was presented in syllables whose pinyin spelling represents all vowels, and in syllables whose spelling omits the main vowel. It was hypothesized that CFL learners would not pronounce the main vowel as a separate phoneme in syllables whose spelling does not include it. This would confirm that the vowel omitted in the phoneme counting task was indeed the main vowel, and therefore confirm that the main vowel is not part of learners' mental representations of these syllables.

EXPERIMENT 1
Participants
Eighteen first-year students of Chinese as a Foreign Language (CFL) were recruited at a British university (10 males and 8 females, mean age=22). They had similar linguistic and writing system backgrounds. Most of them (83%) had studied Chinese for 8 months (the mean was 9 months, ranging from 8 to 23). They were all native readers of the roman alphabet (English=15; other European languages=3), and had all learnt pinyin as the first phonetic transcription system for Chinese. Most of them (83%) had never used other transcription systems (two participants also used Wade-Giles and one used *zhuyin fuhao*); and for most of them (94%) pinyin was the most frequently used transcription system, used 'very often' or 'often'.

Materials and procedure
A printed questionnaire was prepared. The first page contained the instructions, the fourth page contained questions about the participant's biographical and linguistic background, and the two central pages contained a hanzi (Chinese characters) list. Hanzi were used to elicit the target syllables: since hanzi do not represent phonological information, hanzi-naming can be used in the same way as picture-naming. All hanzi had been learnt in class and were present in the learners' textbook (T'ung & Pollard 1982). Each hanzi was presented on a separate line, followed by a 5-option multiple choice, the English translation and examples of Chinese words containing the hanzi, taken from the textbook.

Each of the three rimes under examination ([iou], [uei], [uən]) appeared in 6 hanzi. These rimes were selected because previous research had shown that learners delete them. Four hanzi represented a phonology-orthography inconsistent syllable composed of consonantal onset and rime; e.g., 秋, 休, 酒 and 六, which represent respectively [55], [55], [214] and [liou51] and are spelled as <qiu>, <xiu>, <jiu> and <liu>. Two hanzi represented a phonology-orthography consistent syllable with no consonantal onset; e.g., 有 and 右, which represent [iou214] and [iou51] and are spelled <you>. Given the potential confounding variable of tones, an attempt was made to present all rimes half of the times in the first or second tone and half of the times in the third or fourth tone, but this was not always possible due to the learners' limited knowledge of hanzi. Seventeen more hanzi were added to check that participants were performing the task correctly and to dissimulate the purpose. Table 2 shows the 18 target syllables and the hanzi used to elicit them.

Rime	Syllable	Tone	Hanzi	Pinyin
iou	tɕʰiou	1	秋	qiū
	ɕʰiou	1	休	xiū
	tɕiou	3	酒	jiǔ
	liou	4	六	liù
	iou	3	有	yǒu
	iou	4	右	yòu
uei	xuei	2	回	huí
	ʂuei	3	水	shuǐ
	suei	4	岁	suì
uei (cont.d)	tsuei	4	最	zuì
	uei	2	为	wéi

Rime	Syllable	Tone	Hanzi	Pinyin
	uei	4	喂	wèi
uən	suən	1	孙	sūn
	tsʰuən	1	敦	dūn
	tʂuən	2	伦	lún
	luən	3	准	zhǔn
	uən	2	文	wén
	uən	4	问	wèn

Table 2. The 18 target syllables arranged by type of rime.

Students indicated the number of 'sounds' in each syllable by ticking the correct answer out of a 5-option multiple-choice question (the options were '1, 2, 3, 4, unknown'). Examples were provided, showing that triphthongs counted as 3 sounds and nasals as 1 sound. All participants were given the questionnaire at the same time in their classroom. Participation was on a voluntary basis and there was no time limit.

Results

The average number of phonemes counted was computed for each participant for each type of rime. For syllables containing a consonantal onset, the number of phonemes in the rime was obtained by subtracting 1 from the total number of phonemes counted by the participant. The numbers of phonemes identified in each type of rime were analysed through an analysis of variance (ANOVA) with two within-subject factors: phonology-orthography consistency (consistent or inconsistent) and type of rime ([iou], [uei] or [uən]). There was a highly significant main effect of phonology-orthography consistency, $F(1, 17) = 109.26$, $p < .001$, $\eta^2 = .87$, with more phonemes counted in rimes whose pinyin representation includes the main vowel (mean 2.65, *sd* .07) than in rimes whose pinyin representation does not include the main vowel (mean 1.91, *sd* .10). Although in phonology-orthography inconsistent syllables participants counted more phonemes in [uei] rimes (mean 2.00, *sd* .46) than in [iou] and [uən] rimes (mean 1.87, *sd* .43; mean 1.87, *sd* .49, respectively), the difference was not significant, $F(2, 34) = 1.35$, ns.

Although each type of rime had been presented in 3 or 4 different tones in order to control for effects of tone, tone significantly affected the number of phonemes counted in phonology-orthography inconsistent syllables. A Repeated Measures ANOVA was used to analyse the effects of phonology-orthography consistency (2 levels: consistent and inconsistent) and tone (2 levels: tones 1 and 2; tones 3 and 4). The main effect found for tone, $F(1, 17) = 11.28$, $p < .005$, was caused by the consistency x tone interaction, $F(1, 17) = 9.73$, $p < .01$. With phonology-orthography inconsistent syllables participants counted more phonemes in the third and fourth tones (*M*=2.05, *SD*=.45) than in the first and second tones (*M*=1.77, *SD*=.39); the difference was statistically significant, $t(17) = -4.46$, $p < .001$. With consistent syllables, tone did not affect the number of phonemes counted, $t(17) = .15$, ns.

The main finding of this study was that the orthographic representation of Chinese syllables in pinyin affects the mental representations of Chinese syllables in beginner learners of Chinese. When pinyin spellings do not represent the main vowel in the three rimes under

analysis, Chinese language learners count one less vowel in the rime than they count when the pinyin spelling represents the main vowel as well.

An alternative explanation is of course possible: in performing this phonological awareness task, learners could have adopted an orthographic strategy, i.e. they could have counted one phoneme for each letter, rather than analysing their phonological representations of these syllables. If this was true, the main vowel would not be counted or segmented because it is not present in the written form, and this task would not reveal anything about learners' phonological representations. But it is obvious that participants were not relying on an orthographic strategy, for at least two reasons. First of all, quite a few responses were not in line with a simple orthographic strategy: 44% of participants provided at least one response which was not in line with the number of written letters (e.g., counting 3 vowels in the syllable <jiu> ≡ [tɕiou]). If filler items are also taken into account, all the participants gave at least one orthography-inconsistent answer, for instance counting 3 phonemes in the syllable [yan] although it is spelled <yuan>. Orthography-inconsistent answers confirm that participants were performing phonemic analysis rather than relying on an orthographic strategy. Second, the number of phonemes counted was affected by tone. As discussed above, some researchers hold it that the main vowel is more salient in the third and fourth tones (Norman 1988). The fact that participants counted more phonemes with these tones confirms that participants were analysing their mental representations of Chinese syllables, rather than the pinyin orthographic representations.

It appears that the orthographic representation interacts with the phonological input in determining differences in the mental representations of these rimes. When the main vowel is represented in the orthographic input, it is always present in learners' mental representations, even in first and second tone syllables in which it could be less conspicuous. When the main vowel is not present in the pinyin spelling, it can still be present in learners' mental representations of third and fourth tone syllables, in which it could be more conspicuous.

Results clearly show effects of L2 orthography on the mental representation of Chinese syllables in beginner learners of Chinese as a Foreign Language. It is on the other hand evident that phoneme counting tasks do not provide information as to what is being counted. Participants did not always count 3 phonemes even in rimes that are spelled with 3 letters, and in general the average number of phonemes counted was lower than expected, in both phonology-orthography consistent and inconsistent syllables. For this reason, a phoneme segmentation task was used to investigate which phonemes were not counted by learners. Oral phoneme segmentation tasks require participants to pronounce phonemes aloud one by one, and therefore clarify what they consider a phoneme. A small-scale experiment was then used to confirm that the vowels omitted in the phoneme counting task were indeed the vowels not represented in pinyin orthographic representations.

EXPERIMENT 2
Participants

Five beginner learners of Chinese who had not participated in the first experiment were recruited at a British University. There were 2 males and 3 females, with an average age of 21 (ranging from 19 to 22). Most of them had studied Chinese for 14 months (60% of participants; the mean was 24 months), and none had ever lived in a Chinese-speaking country. All participants were native readers of the roman alphabet (English=2, other European=2, Indonesian=1). On average they devoted one hour a day to reading, one to writing, one to speaking, and less than an hour to listening. They all learnt pinyin as their first transcription system and did not use any other transcription systems; they reported using pinyin 'very often' or 'often'. They considered a native-like pronunciation 'very important' (60%) or 'important' (40%).

3.2 Materials and procedure

The same 18 hanzi (and 17 fillers) used for the phoneme counting task were presented for oral phoneme segmentation. They were printed on a booklet containing examples and translations as in the phoneme counting task, preceded by instructions and followed by questions about biographical and linguistic background. Participants first read the hanzi aloud, then pronounced each single phoneme separately; for instance, they segmented 生 as follows: [ʂəŋ], [ʂ], [ə], [ŋ]. Participants were told that they should provide their best pronunciation for each of the sounds in each syllable. Examples showed that triphthongs had to be segmented in 3 phonemes and nasals had to be pronounced as individual phonemes.

3.3 Results and discussion

Participants segmented [iou], [uei] and [uən] into three phonemes in syllables spelled with the main vowel (e.g., <you>), and into two phonemes in syllables spelled without the main vowel (e.g., <liu>). The average number of phonemes segmented in each rime was 1.98 (*sd* = .10) in phonology-orthography inconsistent syllables and 3 (*sd* = 0) in consistent syllables. Among inconsistent syllables, learners segmented on average 1.94 phonemes in [uei] rimes (*sd* = .13), 2.05 phonemes in [iou] rimes (*sd* = .11) and 1.95 phonemes in [uən] syllables (*sd* = .11).

The number of phonemes segmented was analysed using an analysis of variance, with two within-subject factors: phonology-orthography consistency (consistent or inconsistent) and type of rime ([iou], [uei] or [uən]). There was a highly significant main effect of consistency, $F(1, 4) = 539.69$, $p < .001$, $\eta^2 = .99$. The effect of type of rhyme was nonsignificant, $F(2, 3) = 1.00$, ns.

The phoneme segmentation task confirms results from the phoneme counting task. In most cases, rimes were segmented as they are spelled. [iou] is segmented as [i·u] when it is spelled <iu> and as [i·o·u] when it is spelled <you>, [uei] is segmented depending on its spelling as [u·i] (≡ <ui>) or [u·e·i] (≡ <wei>) and [uən] as [u·n] (≡ <un>) or [u·e·n] (≡ <wen>). While the results appear neat, especially considering the small number of participants, an analysis of the type of phonemes segmented in phonology-orthography inconsistent syllables revealed a more complex picture. Sometimes, the participant segmented a triphthong into two vowels, but one of the vowels was in fact a diphthong, for instance segmenting [uei] as [u] and [ei]. Although the number of phonemes segmented was two rather than three, all vowels were present, with a diphthong being counted as a single vowel. One participants segmented [iou] as [i·u:], lengthening the vowel [u:] to replace the missing diphthong [ou]. Participants were not always self-consistent in their segmentations: one participant segmented [uei] twice as [ue·i] and twice as [u·ei]; another segmented it as [u·i], [u·e] and [u·ei].

Results from this small-scale segmentation task therefore confirmed the results of the phoneme counting task, showing that the phoneme omitted in counting is indeed the main vowel. These findings also completed the picture by showing that different learners solve the phonology-orthography inconsistency in different ways. The occasional presence of more than one segmentation in the same learner testifies that his/her L2 phonological system is not stabilised yet. At least at this beginner level, orthography determines how phonemes are counted and segmented, but different learners find different solutions to the problem of the inconsistency between what they hear and what they see.

GENERAL DISCUSSION
Summary

Results from both the phoneme counting task and the phoneme segmentation task demonstrate a strong effect of pinyin orthographic conventions on the phonological representations of beginner learners of Chinese as a Foreign Language (CFL). Learners omitted one vowel in all the three phonology-orthography inconsistent rimes, both in the phoneme counting task and the phoneme segmentation task. The results from these two phonological awareness tasks explain previous findings that CFL learners sometimes omit the main vowel

from these rimes. It appears that the orthographic representation is interpreted in terms of the first language grapheme-phoneme conversion (GPC) rules, rather than the second language orthographic conventions. By relying on both the L2 phonological input and the L2 orthographic input (reinterpreted according to L1 GPC rules), beginner learners of Chinese create a mental representation of the target syllables which is not target-like and which, besides affecting their performance in phonological awareness tasks, also affects their actual L2 production. On the other side, the inconsistency of responses in the phoneme segmentation task shows that there is variability both between and within learners. The learners who produced more than one segmentation for the same rime testify of a phonological system still in development, where the contrast between the orthographic and phonological inputs has not been solved yet.

Throughout this paper, it was argued that the absence of the main vowel in L2 learners' production of these syllables is due to the effects of L2 orthography on L2 phonological representations. The following section will discuss whether alternative explanations are possible.

Could the absence of the main vowel be attributed to other causes?

In the literature, CFL learners' non-target-like pronunciations of Chinese rimes are generally attributed to the effects of pinyin representations (Bassetti forthcoming, Ye et al. 1997), but other factors could be responsible. These include: articulatory difficulties, phonological input or characteristics of the deleted vowels. These alternative explanations will be discussed below.

One reason why CFL learners omit vowels from Chinese rimes could be articulatory difficulties. It is known that triphthongs and diphthongs are difficult to pronounce, and for this reason they can be reduced by inexperienced speakers, such as young children and L2 learners. The absence of the main vowel in L2 learners' mental representations and pronunciations could be due to their difficulty in articulating two or three vowels in a rapid sequence. But a comparison of L2 learners' phonology with Chinese children's early phonology reveals that this cannot be the reason.

Chinese children often reduce triphthongs to diphthongs, and diphthongs to monophthongs: they reduce 67% of tri- and diphthongs at age 2, 48% of triphthongs and 38% of diphthongs at age 3, and 23% and 19% respectively at age 4 (Li et al. 2000). In reducing tri- and diphthongs, Chinese children eliminate one vowel, but the main vowel is always pronounced; for instance they pronounce [uei] as [ei], and [iɑu] as [iɑ] or [ɑu] (Zhu & Dodd 2000). This can be explained as a consequence of phonological saliency: since the middle vowel is longer and louder, it is more salient (Li et al. 2000; Zhu 2002). The main vowel is noticed in the input, and therefore it is present in the output.

Comparing findings from Chinese children (in Zhu, 2002) and findings from L2 learners of Chinese (Bassetti forthcoming; Ye et al. 1997), it appears that adult L2 learners' reductions differ from Chinese children's:

1) adult L2 learners eliminate the main vowel, which Chinese children never eliminate, i.e. whereas Chinese children pronounce [uei] as [ei], L2 learners pronounce [uei] as [ui];

2) Chinese children's reductions occur in all contexts, whereas adult L2 learners' reductions only occur in post-consonantal contexts, i.e. L2 learners reduce [tiou] to [tiu] but not [iou] to [iu];

3) the most affected rimes are not the same: whereas Chinese children reduce [iɑu] the most (37% of children in Hua and Dodd, 2000), followed by [uei] (10% of children), L2 learners reduce [uei] but not [iɑu]. Although there is no data on L2 learners' acquisition sequence, this could also differ, as Chinese children correctly produce [iou] earlier than [iɑu], whereas L2 learners produce [iɑu] but not [iou] correctly.

The cause of the L2 learners' non-target-like pronunciation of these rimes cannot therefore be the difficulty in articulating the sounds. The absence of the main vowel cannot be explained in terms of phonological input either, because the vowel L2 learners omit has the most intensity and length in the rime. Some researchers hold it that the main vowel in these rimes is less prominent in the first and second tones; learners could therefore not perceive the main vowel in the first and second tone because it is less salient. But this never occurs in Chinese children's early phonology, and it does not explain why the same vowel is always pronounced in phonology-orthography consistent syllables, although it is less prominent in both consistent and inconsistent rimes. It appears that the only explanation for the L2 learners' non-target-like pronunciation is the effect of orthography on their phonological representations.

How and why does the L2 orthography affect L2 phonology?

Native speakers of Standard Chinese are exposed to Chinese phonology for years before learning pinyin in school. For them, the sequence of letters <iu> is the orthographic representation of [iou]. As Ye and colleagues put it, 'to Chinese people, this rule is logical, because in Chinese there are no [iu], [ui] or [un] rimes' (Ye et al., 1997: 156; translation by the author). That is to say, for a Chinese native speaker <iu> ≡ [iou], <ui> ≡ [uei] and <un> ≡ [uən]. Learners of Chinese as a Foreign Language are exposed to pinyin orthography from the very beginning and without mastering Chinese phonology. When they start being exposed to the written form <iu> they do not know that [iu] is not part of the phonological repertoire of Chinese. On the other hand, if learners were only exposed to spoken and written Chinese they would not pronounce <iu> as [iu], because [iu] is never present in the spoken input, and <iu> is always associated with the sounds [iou] in the classroom. The reason why <iu> is interpreted as [iou] is that CFL learners are already literate in writing systems in which <iu> does not represent [iou]. In English, for instance, <gui> ≡ [gaɪ] or [gɪ]; <sun> ≡ [sʌn], and so on; in no case these two letters represent three phonemes. Also, in pinyin one grapheme (one or two letters) always corresponds to one phoneme with <iu>, <ou> and <un> being the only exceptions. This creates an expectation that two letters will represent two phonemes, which is then generalised to the three inconsistent rimes.

Research on L2 phonology has repeatedly shown that first language phonological categories affect the perception of L2 phonemes, so that for instance Japanese learners perceive both English [l] and [r] as being one phoneme because they are allophones in their first language. The same phenomenon could apply to L2 orthography, which could be interpreted according to the orthography-phonology correspondence rules of the first language. This is the reason why English learners pronounce Chinese $[p^h]$ as [p] and [p] as [b] (Meng, 1997). [p] is pronounced as [b] because it is spelled with <b>, which corresponds to [b] in English (although it corresponds to [p] in Chinese); and $[p^h]$ is pronounced as [p] because it is spelled with <p> (≡ [p] in English; ≡ [p^h] in Chinese). It appears that L2 graphemes are interpreted as representing the same phonemes they represent in the L1, and this affects the mental representations of the L2 phonemes, which are shaped by both the phonological and the orthographic input. The same probably happens at the suprasegmental level with the three rimes investigated in the present paper.

Figure 1 tries to put together findings from the present study and from studies on the effects of orthography on L2 phonology and spelling (Bassetti forthcoming; Okada 2005; Yeh et al. 1997). The Figure represents how L2 orthography could affect L2 phonological representations, and in turn L2 pronunciation, spelling and phonological awareness tasks. The orthographic input is reinterpreted according to the L1 orthography-phonology conversion (OPC) rules, in the same way as the spoken input is affected by the L1 phonological categories.
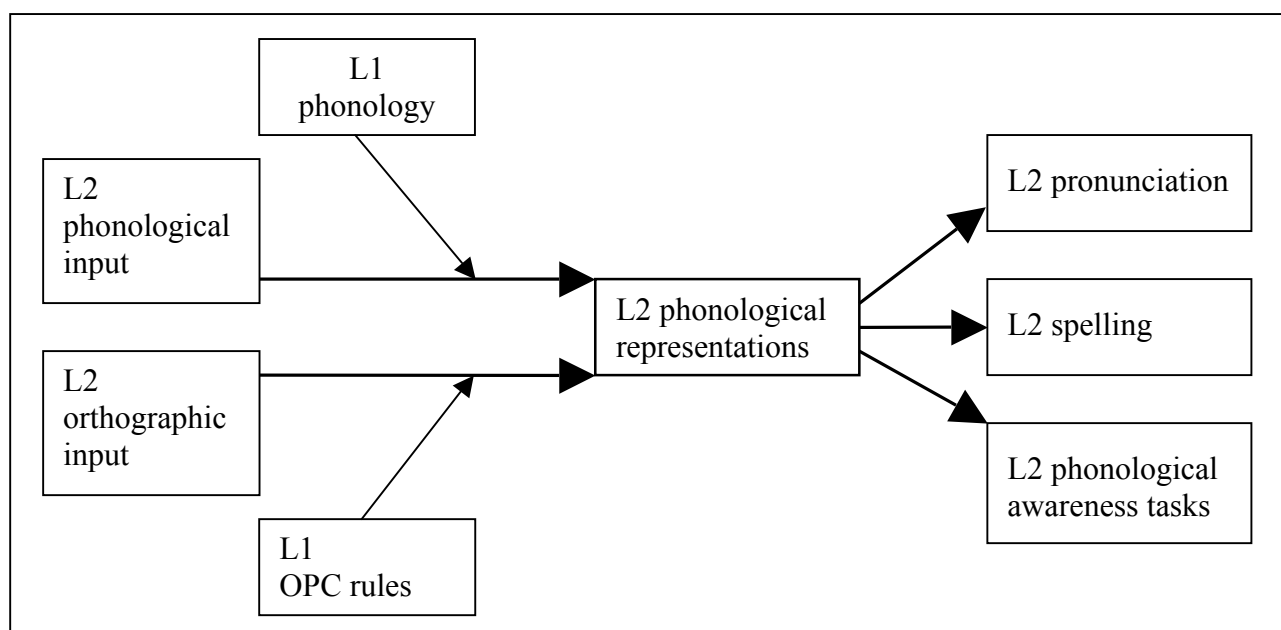
Figure 1. The effects of L2 orthography on L2 phonology

The reasons why the pinyin orthographic input may play such an important role are twofold. First of all, learners of FL Chinese are exposed to pinyin input at the same time as they are first exposed to the sounds of Chinese, and indeed L2 pronunciation is taught through its pinyin representations. Second, pinyin exposure not only takes place from the very beginning, but it is also intensive in the early stages of language acquisition. Most textbooks are written entirely in pinyin for part or the whole of the first-year (e.g., *Colloquial Chinese*, T'ung & Pollard 1982; *Practical Chinese Reader,* Beijing Language Institute 1986). After this initial period, learners still use pinyin to check dictionaries, jot down the pronunciation of unknown hanzi, etc.

CONCLUSIONS

In investigating the development of second language phonology, the main factor is often identified as being the presence of a first language phonology in the L2 learner's mind. The presence of another language in the learner's mind is probably the main difference between adult foreign language learners and monolingual children acquiring their first language phonology. But there is another difference, which is almost always ignored. Adult FL learners are in most cases literate. They therefore receive different input compared with native children, because much of their input is written rather than spoken language; and they can reinterpret this written input according to the orthography-phonology correspondence rules of their first language writing system, whereas for native children written language is just the representation of a previously acquired phonological system.

This way, the orthographic input affects learners' L2 phonological representations, leading to non-target-like pronunciations that never occur either in the spoken input learners are exposed to or in native children's early phonology. The effects of orthography therefore extend beyond the realm of the written language to affect the spoken language, and beyond affecting (arguably unnatural) phonological awareness tasks to affecting actual language use. Given the important effects of L2 orthographic representations on L2 phonological representations, it is proposed that research on L2 phonology should take the orthographic input in consideration more than it has hitherto been the case.

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[1] The status of [i] and [u] is debated, as some researchers consider them semi-vowels and others vowels.