Associative Priming of Non-word Dictation Among Young ESL Learners with Chinese Language Backgrounds

Chao Zhang

Department of Educational and Counseling Psychology

McGill University

Montreal, Quebec, Canada

June 2013

A thesis submitted to McGill University in partial fulfillment of the requirement of the degree of Master of Arts in Educational Psychology, Human Development

Table of Contents

List of Tables

Abstract

The present study adopted Seymour and Dargie's design (1990) and examined the associative priming effect on English non-word spelling in young ESL learners with Chinese language backgrounds. Participants were either assigned to an unprimed non-word dictation condition or a primed condition where the non-word was preceded by a prime which is semantically associated to a word that rhymed with the target non-word. The orthographical choice of vowel pattern in the non-word dictation task for young ESL learners greatly depends on its contingency. The results in the present study indicated that the children with higher reading proficiency were more sensitive to high contingency vowel spelling patterns. The additive associative effect revealed in adult English speaking populations (Seymour & Dargie, 1990) was not evident in the current study with young ESL learners. This data adds to our understanding of contingency effects by extending research to ESL samples and aids in the development of the broader view of understanding the nature of mechanisms underlying sub-lexical spelling processes in L1 and L2 contexts. Some implications for the dual route model and linguistic transfer theory are discussed.

Résumé

La présente étude a adopté le modèle de Seymour et Dargie (1990) et a examiné l'effet d'une amorce associée à un non-mot anglais sur la capacité à orthographier celui-ci chez les jeunes chinois apprenants l'anglais comme langue seconde. Les participants ont été assignés à deux conditions distinctes. Les élèves ont été évalués à l'aide d'une dictée de non-mots dans la première condition tandis que les élèves dans la deuxième condition ont dû effectuer une dictée de non-mots où ceux-ci était précédés par un mot sémantiquement associé au non-mot et rimant avec celui-ci. Les résultats ont démontré que le choix orthographique des voyelles dans la tâche de dictée de non-mots pour les jeunes apprenants l'anglais comme langue seconde dépend grandement de la contingence de celle-ci. De plus, ceux-ci ont également indiqués que les enfants ayant une meilleure compétence en lecture seraient plus sensibles à l'orthographe de voyelles de haute contingence. Dans la présente étude œuvrant auprès de jeunes apprenants l'anglais comme langue seconde, l'effet « associatif additif » révélé dans les populations d'adultes anglophones de l'étude de Seymour et Dargie (1990) n'était pas prédominant. Ces données aident notre compréhension des effets contingence en étendant la recherche aux échantillons ALS et aident à l'élaboration de la vision plus large de la compréhension la nature des mécanismes qui sous-tendent les processus d'orthographes sous-lexicales en L1 et L2 contextes. Quelques implications pour le modèle à double entrée et pour la théorie du transfert linguistique seront abordées à l'intérieur de la discussion.

Acknowledgements

I would like to express the deepest appreciation to all those people who provide the possibility to complete this thesis. Many thanks go to my parents for their endless love and support without which I could not have completed my study. I would also like to thank Charles, Jie Yang and Hui Zhao who are witnesses of my graduate life. A special gratitude I would like to give to my supervisor, Dr. Robert Savage, for his guidance and support. Finally, I would like to thank all the lovely ladies in Dr. Savage's lab who fulfill my graduate time with beautiful memories and generous help.

Preface

This thesis is an original, unpublished, and independent work by Chao Zhang.

Introduction

Society is increasingly globalized and multicultural in nature. The international nature of communication inevitably creates a great need for multilingualism. Due to this, in the year 2000, the Chinese government launched a systematic English instruction program throughout elementary schools to higher educational institutions. By 2006, there were already more than 300 million people, almost a quarter of China's population, putting effort into learning English (Chen, 2006). Meanwhile, in the English-dominated regions of the world, for example, North America, the inflow of immigrants of Chinese origin is growing considerably. In Quebec, Canada, the most recent census revealed that China has become the fourth largest immigration source accounting for 5.6 % of Quebec's immigrants from 2001 to 2010 (Miron & Filip, 2012). With the need for Chinese speakers learning English as a second language rising worldwide, there is also an increasing demand for exploring the underlying developmental connections between the first language (L1) and the second language (L2). Fortunately, this now worldwide multilingual environment has provided researchers a fertile breeding ground within which to explore this question.

From a linguistic perspective, Chinese and English writing scripts each belong to two major broad types of written language: alphabetic language and "morphosyllabic" language. The former applies the alphabetic system using letters as the smallest writing unit, and often follows phoneme-to-grapheme mapping rules. Chinese is considered a "morphosyllabic" language because of its written form containing both the information of syllable and morpheme

(McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003). A rich literature on monolinguals of these two languages (i.e English and Chinese) has investigated the relationship between the acquisition of language and the development of cognition. Yet, the study on Chinese-English bilinguals relating to their development of language information processing is still rare. The present study aims to examine the underlying processing mechanisms between the first language (L1) and the second language (L2) by targeting the participants who are exposed to two languages with distinct writing forms. The current finding is also expected to shed a light on further implications on individual language development and practical policies in the current educational environment.

Literature Review

To date, there are four main streams of research that inform alphabetical spelling: neuropsychological research (Morton, 1980; Rapp, Epstein, & Tainturier, 2002; Seymour & Porpodas, 1980; Tainturier & Rapp, 2001), developmental modeling of spelling (Treiman, 1993; Young, 2007), the literacy skills related to spelling performance (Kahn-Horwitz, Sparks, & Goldstein, 2012; Treiman & Bourassa, 2000), and the genetic influences on spelling performance (Bates, 2006; Bates et al., 2007). However, compared to the research on reading, there are limited studies looking at spelling. Much empirical evidence about spelling results from close examination of neurological patients. The central theoretical positions that seek to explain spelling are: (1) dual route models, and (2) single interactive path models.

Dual route spelling mechanism: lexical route and sub-lexical route

Seymour, Porpodas (1980) and Morton (1980) first proposed a dual route spelling model adapted from the two-channel reading theory (e.g., Coltheart & Byng, 1989; Coltheart , Curtis, Atkins & Haller,1993) . This theory highlights the possibility of the existence of two functionally independent approaches for native speakers spelling English words.

One approach is to produce spelling through a direct sound-to-spelling conversion which requires the knowledge of phoneme-grapheme (P-G) correspondence. This sub-lexical mapping strategy (also referred to as indirect phonological route) will be applied to the spelling of novel words. The other is retrieving orthographical representation from lexicon memory (referring to word-specific processes, or the direct visual route), during which the semantic unit could be selectively activated depending on the demand of the task (Tainturier & Rapp, 2001). This lexical-semantic path is used in spelling familiar words irrespective of their degree of regularity, and is more applicable for skilled readers. These two pathways are assumed to be applied autonomously during the spelling process. Within this idea of double dissociation, the processing of non-words only relies on the non-lexical route because they should not be stored in the lexicon memory.

Neuropsychological data from impaired individuals has solidly supported the dual route assumption by describing the two distinct dysgraphia subtypes in both developmental and acquired agraphia populations (Cotelli, Abutalebi, Zorzi,

& Cappa, 2003; Funnell & Davison, 1989; Kohnen, Nickels, Brunsdon, & Coltheart, 2008). Surface dysgraphia patients who suffer from selective impairments in lexical-semantic mechanisms have a much harder time spelling familiar words than novel words because of the difficulty in retrieving words from memory; whereas patients with phonological dysgraphia experience a more difficult time spelling novel words due to their selective impairment in the procedure of converting phonemes to graphemes (Miceli & Capasso, 2006). In addition to the empirical support from direct observations, supportive evidence also comes from computational modeling (Castles, Bates, & Coltheart, 2006; Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Rapcsak, Henry, Teague, Carnahan, & Beeson, 2007). Rapcsak and colleagues have applied the model to accurately predict the reading and spelling performance on irregular words and non-words in adult patients with acquired dysgraphia. According to the dual route theory, irregular words (IRREG) and non-words (NWD) can only be processed through the lexical-semantic approach and sub-lexical path respectively, whereas regular words (REG) can be processed through either of these two routes. The researchers argued that in this sense, the accuracy of processing regular words would be predicted by the processing capacities of irregular words and non-words. The proportions (p) of these three types of words that a person could correctly process would be a good estimation of his/her processing capacity. Therefore, the equation is as following:

$$p(REG) = p(IRREG) + [1 - p(IRREG)] \times p(NWD)$$

The regression model predicts 88.8% and 92.1% of variance in regular words reading and spelling, respectively. Their findings have extended Coltheart et al's (2006; 2001) previous work by stating that reading performance in young participants with normal or impaired reading capacity could be precisely predicted using the same equation (Castles et al., 2006; Coltheart et al., 2001).

How does the sub-lexical route function in the non-words spelling task within the dual route model?

Though evidence exists for the dual route, the specific operating mode of the sub-lexical route is still ambiguous. Barry and Seymour (1988) attributed this lack of specification to the ambiguous nature of the English writing system. As is well known, the English orthography system carries a notoriously inconsistent relationship of phonemes-to-graphemes (P-G) compared to other alphabetic languages (such as Spanish) which almost have a one-to-one P-G mapping. This absence of one-to-one mapping relationship in phoneme-to-grapheme conversion in English is particularly obvious in vowels. For example, /ɔ:/ can be spelled as "or", "aw", "au", "ore", "al", "ar", "our", "oar", "our", "ough", "augh", "oa", "awe", and "o" (Barry & Seymour, 1988). However, each spelling pattern does not occur with the same probability in the English lexicon: some P-G mappings occur more frequently than others. According to the pattern occurrence in English words, vowels are categorized into two groups, consistent and inconsistent vowels. For five "short" vowels, as /i/ in "which", /e/ in "letter", /ɔ/ in "hot", /ʌ/ in "sun", and /æ/ in "pap", are considered as consistent vowels because their most common

patterns contribute to more than 90% of the spellings in English lexicon. For the rest of the vowels, treated as inconsistent, the most frequent spelling pattern occurs in less than 70% of words. The inconsistent words could be classified as either high P-G contingency spelling (occurring most frequently) or low P-G contingency spelling (occurring less frequently). For example, "oo" is a high contingency spelling for /u:/, as in "moon", since it occurs in 40% of words; whereas "oe" is a low contingency spelling for /u:/ due to its less than 5% occurrence in words.

With the concept of P-G contingency, Barry and Seymour (1988) explained how non-words were spelled by using a P-G conversion process. Logically, the production of non-words spelling patterns in a free context, especially the vowels, would reflect the P-G contingency. In other words, the participants would be more likely to adopt the vowel patterns with a high P-G contingency in non-words spelling tasks than the one with a low contingency. For example, for the vowel /ɔi/, 77% of the participants spelled as "oi" (occurs in 67.7 % of words) compared to 6.8% of them spelled as "oy" (occurs in 27.2% of the words) in the free spelling task. The researchers concluded that the P-G contingency would account for significant variance in non-words spelling in a free context. In Seymour's subsequent study (1990), he reassigned the free-context non-words spelling task to adult English speakers, and reconfirmed his findings by revealing a significant high bias for high P-G contingency spelling patterns over low ones. Although the strong sensitivity of contingency in the P-G

conversion embedded sub-lexical route has been verified in English speakers, there is still a lack of solid evidence from those who learn English as a second language (ESL). This issue is explored in the present study.

Challenges to the dual route assumption from non-words spelling tasks

While the dual route theory has gained empirical support, debate in recent decades has yet again caused the dual route model to be reconsidered. Researchers' findings from the normal participants' non-words spelling performance seriously challenged the assumptions in dual route model that the non-word can only be spelled by P-G conversion. They (Barry & Seymour, 1988; Campbell, 1983; Cuetos, 1993; Folk & Rapp, 2004; Seymour & Dargie, 1990) have questioned the independence of the two approaches, and found that the process of spelling non-words is also open to the lexical-semantic influence, which has been detected in three directions: phonology, orthography and meaning.

Phonology is regarded as the most influential effect on the process of sub-lexical P-G conversion selection. Based on the lexical priming paradigm, Campbell (1983, 1985) found that both children and adults tended to spell the non-words in a similar way with the words they had heard earlier. For example, they were likely to spell "praine" after hearing "brain". Moreover, this tendency has been confirmed by the following research targeting different participants, even in different languages (Barry & Seymour, 1988; Campbell, 1983; Cuetos, 1993; Folk & Rapp, 2004). In addition to phonological effects, the orthographical influence on non-word spelling was also examined. Folk and Rapp (2004)

conducted a study to examine which primes would be more dominant in non-words' spelling, phonology or orthography. They produced two types of testing materials, phonological overlap primes and orthographical overlap primes. The proportions of the target non-word / nʌtʃ/ being produced as "nouch" proceeded by a phonological prime "touch" or an orthographical prime "couch" were compared. Results have shown that after controlling the primary phonological lexical priming effect on P-G conversion, the target orthographical representation was also activated by the lexical prime (Folk & Rapp, 2004)). Lastly, the effect of meaning was analyzed by Seymour and Dargie (1990). They designed a non-word spelling dictation task with a free-context condition and an experimental condition. The participants in the free condition were asked to produce the plausible orthographical representation for the target non-word; whereas in the experimental condition, the non-word was preceded by a prime, which was semantically associated to a word that rhymed with the target non-word. If it is true that the lexical primes affect the sub-lexical route in a semantic way, the participant would be expected to spell the target non-word /wi:s/ as "weace" if the preceding prime is war, because "war" will activate its semantic associated pair "peace" which is phonologically related to a share rhyme with the target non-word (war-(peace)-weace). Similarly, the target non-word /wi:s/ would be spelled as "wiece" if the preceding prime is "nephew" (nephew-(niece)-wiece). The result showed that P-G contingency and associative priming both influenced the non-words spelling pattern. This associative priming effect on orthographic choice in

non-words reading was also supported by Rosson (1983) (experiment 3) and Pring & Snowling (1986).

Single interactive path models

Since the aforementioned findings evidently challenge the dual route theory by postulating the potential link between a lexical input and a non-lexical output, researchers tried to modify the dual-route theory by suggesting that these two paths could interact with one another, or put forward an alternative single connectionism model. To date, this interactive route theory, based on parallel distributed processing (PDP) has gained support in the literature (Barry & De Bastiani, 1997; Barry & Seymour, 1988; Campbell, 1983, 1985; Folk, Rapp, & Goldrick, 2002; Hillis & Caramazza, 1991; Hillis, Rapp, & Caramazza, 1999; Houghton & Zorzi, 2003; Rapp et al., 2002; Seymour & Dargie, 1990). The connectionist theory has also been widely discussed (Harm & Seidenberg, 1999; Plaut, 1997, 1999, 2002; Plaut & Booth, 2000; Plaut & Gonnerman, 2000; Plaut & Kello, 1999; Plaut, McClelland, Seidenberg, & Patterson, 1996). The PDP theory posits a triangular model to explain the interactive relationship among orthography, phonology, and meaning by way of a connectionist network. There are several hidden units mediating the pathway from input to output. By altering the weights and distribution in the connected relationships, the yielded output from input differs. Therefore, the different input patterns (primes) activate and adjust the weights to the different hidden units (mediators), which result in different outputs (non-words spelling patterns).

Again, compared to the main body of evidence challenging Dual-route theory stemming from additive phonological effects on non-words spelling, there is little evidence of semantic priming effects from young participants whose cognition is undergoing developmental changes. Beyond this, compared to the extensive research targeting English native speakers, there has not been a study testing the underlying processing mechanism of English among ESL learners until recently. The present study aims to bridge the gap by exploring the potential associative priming effect in English non-words spelling with young Chinese speakers of English as a second language.

Cross-linguistic transfer from L1 Chinese to L2 English

In order to examine the English spelling process within ESL participants, it is important to fully understand how English is represented in the minds of ESL learners. Major (2001) postulated an inter-language hypothesis which suggested that there were three parts embedded in the second language system among second language learners: the language they are learning (L2), their native language (L1), and the universal parts of language. In this sense, the acquisition process of English could vary for ESL learners based on their diverse mother tongues. Due to the fact that all the languages involve phonology, phonological processing is a universally transferable skill across languages. Yet the transfer would be more limited between two languages where phonological and orthographical (P-O) mapping occur at different levels (e.g., Chinese at the syllable level, English at the phoneme level) compared to two languages with

similar P-O mapping systems (e.g., English and French, both operating at the phoneme level).

In addition to the phonological factor, the writing system to a great extent determines the quality and quantity of transfer occurring between L1 and the acquisition process of L2 (H. C. Chen & Tsoi, 1990; Geva & Siegel, 2000; McBride-Chang, Wagner, Muse, Chow, & Shu, 2005; McBride–Chang & Kail, 2002). In recent decades, this topic has generated a great amount of interest from researchers. Perfetti, Cao, and Booth (2013) thoroughly reviewed the universal and distinct features of Chinese and English to provide a more universal angle on the science of reading. It has also been assumed that orthographic processing skill is non-transferable and more related to specific written systems (Gottardo, Yan, Siegel, & Wade-Woolley, 2001; Lipka & Siegel, 2007; Wang, Perfetti, & Liu, 2005). Holm and Dodd (1996) discovered that Chinese ESL learners would rely more on visual strategy which is required in processing whole words due to their underdevelopment in phonological awareness. Leck, Weekes, and Chen (1995), Wang and Geva (2003), and Leong, Tan, Cheng, and Hau (2005) also found that, in order to compensate for the shortage of phonological processing skills in Chinese, Chinese ESL learners develop greater orthographic and lexical knowledge in English reading. This finding is in accordance with conclusions reported in the study of Yeung et al (Yeung et al., 2011). Therefore, the advanced development in lexical processing in English reading has been solidly documented in Chinese learners of ESL. In contrast, how this merit serves in

English spelling is still unknown. For this reason, it would be interesting to examine it in a cross-linguist context with a spelling task.

Semantic activation in Chinese

Chinese is a "logographic" language, because the character represents more meaning than phonology. It is also known as "morphosyllabic" since the orthography contains both the information of syllable and morpheme (McBride-Chang et al., 2003). This indicates that the orthography processing of Chinese requires a word-morphology basis instead of a word-phonology route. There are two types of Chinese characters: integrate character and compound character. An integrate character is more like a picture or a symbol: it is inseparable and made of criss-cross strokes, and the correspondence of its phonology and meaning is often learned by rote (e.g., 又, pronounced "yòu", meaning *again*). The route to Chinese lexical access for integrate words relies more on a visual route instead of phonological pathways. Leck, Weekes, and Chen (1995) experimented on normal adult readers with Chinese integrated characters and compound characters. The results revealed that the recognition of integrated characters strongly relied on visual information, for compound characters it depended on visual, phonological, and semantic information.

Compound characters, consisting of identifiable components, often a semantic radical and a phonetic radical, account for 80% to 85% in the whole Chinese lexicon (Kang, 1993; Zhou, 1978). The phonetic radical inconsistently represents the sound of character, whereas the semantic radical always indicates

the meaning of the word. For example, the character "湖" (pronounced "hú", meaning *lake*) has a phonetic half, "胡" ("hú", indicating the pronunciation) and a meaning half "氵" (meaning *water*, conferring the semantic category). It is therefore suggested that Chinese reading is meaning-based (Weekes, Chen, & Lin, 1998), or at least includes a stronger semantic activation. It is distinctively different from alphabetic languages, not only in the manner of writing, but also in the required sub-linguistic skills involved in language acquisition. Feldman and Siok's study (1999) showed that in Chinese compound characters reading, the semantic radical rather than phonetic component is more likely to be processed during the course of recognition among adults. This sensitivity to abstracting semantic parts might not be specific to Chinese, yet due to the direct link between semantic radical and orthographical representation, it is not surprising to see a more salient effect in Chinese than in other languages, especially alphabetic languages. In Cheng, Caldwell-Harris' study (2010), they compared the semantic and phonological activation during visual Chinese characters and English word reading among Chinese native speakers and English native speakers. They revealed that Chinese reading requires large semantic involvement and less phonological access, in contrast to English reading.

In terms of the P-G mapping system, Chinese also displays distinct characteristics compared to alphabetic ones. Due to the monosyllabic nature of Chinese phonological system, the number of phonological representations in Chinese lexicon is very limited. One sound could always activate multiple

orthographic representations. For example, the sound of “yì” could have 24 orthographic representations as following:

意，义，议，异，译，易，逸，亦

忆，艺，益，役，毅，抑，奕，裔

邑，翼，溢，疫，驿，翌，羿，绎

Therefore, the print of characters can hardly be produced just based on the pronunciations.

With respect to the strong evidence shown in the literature that the reading and writing of Chinese characters relies significantly on semantic activation and visual information processing, it is logical to assume that children with more time dealing with Chinese characters and a higher level of Chinese character writing skills would gain more sensitivity to semantic activation compared to their peers who are alphabetic language speakers. It is also expected that this advantage in semantic-lexical processing might transfer to the acquisition of English. However, to date, investigations into the role of semantic priming effects in ESL children are sparse.

In summary, the previous literature discussed the potential underlying processing mechanism of English among English native speakers, and the strong semantic activation among Chinese native speakers. However, there are neither studies testing the underlying processing mechanism of English among ESL

learners until recently, nor examining the potential linguistic transfer between Chinese and English targeting semantic activation. The present study aims to bridge the gap by exploring the potential associative priming effect in English non-words spelling with young Chinese speakers of English as a second language.

Aims of the Current study

The present study expanded the previous work on ESL children to explore the role of associative priming effect on a non-word spelling dictation task, when preceded by a prime which is semantically related to the word sharing similar vowel pronunciation with the target non-words.

The current study has three purposes. The first one is to examine the sub-lexical English spelling system of ESL learners. As shown in the literature, for English speakers, both early learners and adults, there is a substantial effect of P-G contingency on non-words spelling. If so, then how does this P-G contingency effect work on the non-words spelling performance of ESL children? Will they display similar patterns of phoneme-to-grapheme contingency as native speakers or not? Hence the first research aim of the present study is to examine whether there is significant P-G contingency effect on ESL young learners' non-words spelling performance. Based on the findings of previous studies, it is postulated that the ESL young participants with Chinese as an L1 in the present study would display similar sensitivity to the P-G contingency as the pattern revealed among their native counterparts.

Second, the discussion of the accuracy of the dual route theory mostly

remains centered on research in monolingual populations. For ESL learners, the evidence is still sparse. Will their performance be consistent with the findings revealed in their monolingual peers or not? Therefore, the second research question of current study is to examine whether sub-lexical spelling will show associative priming effects in ESL children who are Chinese native speakers. Since strong semantic activation is involved in Chinese acquisition process, it is expected that the ESL learners with a Chinese language background would show significant associative priming effects in an English nonword dication task.

A third distinct question is: will their performance on English non-words spelling be affected by their first language? More precisely, the goal is to see if the degree of Chinese character knowledge will be an influence on the level of biasing effect. If this semantic priority activation is transferable to the learning process of a second language, for ESL learners, those participants who have a more solid background of Chinese could receive much more benefit in primed non-words spelling than their peers who are less proficient in Chinese. In order to distinguish the Chinese proficiency of participants in the present study, children with Chinese background are recruited in two cities, Beijing, China, and Montreal, Canada. It is postulated that the ESL young learners with higher level of proficiency in Chinese would benefit more on the association priming nonword dictation tasks than those less proficient in Chinese.

In conclusion, the present study intends to explore the nature of English spelling process in two L2 contexts by targeting participants exposed to two

distinct language representations. Three research questions are examined to fulfill the aim of the present study.

1. Overall, if the ESL children with Chinese as an L1 will be sensitive to the phoneme-to-grapheme contingency in English non-words vowel spelling (P-G Contingency effect)?
2. Is the sub-lexical spelling route influenced by lexical semantic information in ESL participants who are Chinese native speaker when they complete non-words spelling task? Specifically, in the present study, the possibility of interactive spelling routes for ESL children will be examined through testing the associative priming effect on non-words vowel spelling task (P-G Contingency x Condition effect).
3. If the second research question had been confirmed within ESL participants with Chinese as an L1, then to what extent is this associative effect on non-words spelling is affected by the proficiency of Chinese character knowledge (Condition x City effect)?

Method

Participants

A total sample of 103 children from Beijing, China, and Montreal, Canada, participated in this study. After the initial approach via parental consent letter, fifty-eight Beijing participants were recruited from a local English training school during the summer of 2012, and another forty five children from Montreal were invited to join in the study during the winter of 2012.

The rationale for using such different groups, which were collected from Montreal, Canada, and Beijing, China, is based on both theoretical and practical considerations. The previous studies targeting cross-linguistic transfer showed that the level of L2 would significantly related to the level of L1. It is logically presumed that the degree of receiving influence of L1 to L2 would also differ from the level of proficiency of L1. The Chinese mother tongue children from both cities share similarities to some extent in their early Chinese acquisition (home language environment). However, through development it is expected that the distinct learning contexts will draw a considerable difference on their Chinese capacity. The aim of the present study is to examine if the two different Chinese capacities represented by two different groups will contribute to significantly distinct performance in English nonword spelling performance. Meanwhile, from the practical perspective, the number of participants in the present study is not sufficient to support two separate analyses. Combining two different groups into one analysis could contribute to a more reliable result and also accommodate economic considerations. The demographic information of the participants was collected through the parent questionnaire. The children in the two cities exhibited both similarities and differences. Ninety seven point eight percent of Montreal children use Chinese at home, and 100% of Beijing children speak Chinese in the home environment. However, the Beijing children continued using Chinese in school context, whereas the children in Montreal speak French in school. Both the father's and mother's educational level in the two cities did not differ from each

other, 82.2% of mothers and 86.4% of fathers in Montreal, compare to 77.8% of mother and 85.1% of father in Beijing, received bachelor or graduate degrees.

In terms of the English learning experience that the students in these two cities have, the time of English instruction received by children was different in both formal schooling and extra curriculum settings. The statistics revealed a trend that Beijing participants spent more hours in English learning compared to their counterparts in Montreal. Only 4.4% of the children in Montreal had formal English instruction more than 4 hours per week; compared to 37.9% of children in Beijing reported the similar time amount spent on the same subject. Outside of school 2.4% of Montreal children will attend extra-curricular English classes; compared to 29.8% of children in Beijing.

Though due to the research time limit, the Chinese character knowledge was not measured among the two populations, there is still some useful data that could aid us to have a better estimation of their overall Chinese capacity. It is suggested that the level of Chinese language among the children from both cities is also substantially different from each other, especially on their knowledge of Chinese characters. According to Chinese text books used by all the participants from both cities, it is expected that by grade 4, Beijing participants would have learned 2000 Chinese characters in both reading and writing manners (Cui & Peng, 2010); whereas, the Montreal children, who were in grade 3 approximately, were expected to know how to read and write fewer than 450 Chinese characters

by the time they took the test (Chinese College, 2007). All the participants in both cities are typical children based on school data.

Overall, these two groups of participants show different profiles in relation to their age, nationality, learning context, and language immersion duration. More demographic information about the participants is shown in the Table 1.

Table 1

Descriptive Information about Participants' Characteristics for Each Group

City	Boy	Girl	Age in month	Grade	Normal School language immersion	Years of learning English	Born in the country where taking the test
Beijing	22	36	121.15 (8.01)	5	Chinese	4.26	China (96.5%)
Montreal	20	25	100.24 (15.46)	3	French	2.68	Canada (77.8%)

Measurement

The aim of this study was to examine the English non-words vowel spelling patterns and skills among ESL learners. A non-words dictation task was assigned to the participants. Additionally, in order to balance the baseline of overall English level among all the children from different cities, English proficiency was examined by using standardized tests (subtests of listening comprehension and sentence reading in the Group Reading Assessment and

Diagnostic Evaluation (GRADE; Williams, 2001)). Parents were also asked to complete a questionnaire related to the information of their child's background and language learning experience.

Experimental Tasks (Nonword dictation). The main design and the non-words selection in this study were adopted from Seymour and Dargie's research (1990) , but with several careful modifications.

Selection of Primes. Based on the Free association norms database from the University of South Florida (Nelson, McEvoy, & Schreiber, 1998), the primes and their semantically associated mediators were selected first. The primes are the words that the participants would receive prior to the nonword spelling task. The mediators are referred to the words which are semantically associated to the primes. The reason for doing so is because of the participants' characteristics in the present study. The children from both cities were learning English as a second language, so their overall English level is obviously limited when compared to the native speakers. In order to eliminate the potential bias embedded in the difference of the participants' vocabulary knowledge, only those prime-mediator pairs, in which both words were familiar to all the participants, were chosen in the present study. The words were considered as "familiar" to Beijing participants only if they had been taught in the English text books used by most of the public primary schools during grade 1 to grade 3 (the mean grade of our Beijing participants is grade 5, and the minimal grade is grade 3) (Liu & Hao, 2005). Meanwhile, those prime-mediator pairs were sent to a Montreal local school

teacher, and she was asked to highlight the words that she assumed beyond the children's English vocabulary knowledge from Montreal. After removing those above-level words, a total 20 prime-mediator pairs, among which every two mediators rhymed with each other, were sent to Dr. Robert Savage for a final review. With the help of Dr. Robert Savage, ten target non-words that rhymed with the twenty mediators were produced.

Phoneme-to-Grapheme Contingency. Following the concept introduced by Barry and Seymour (1988), the Phoneme-to Grapheme (P-G) Contingency refers to the frequency of specific orthographies occurring in the English lexicon. The frequencies were estimated by a computational analysis based on the educated adults' vocabulary system (Barry & Seymour, 1988). Considering the fact that the participants in this study learn English as a second language and their exposure to English is considerably limited compared to their native peers, the consistent vowels and inconsistent vowels are not differentiated in this study as they were in Barry and Seymour's study (1988). The most common spelling pattern for both consistent vowels and inconsistent vowels are considered as high contingency spelling; whereas the other spelling patterns are considered as low contingency spelling. For the ten target non-word vowels, their alternative orthographies with a high P-G contingency and a low P-G contingency were correspondingly rhymed with the 20 mediators. Two versions of word lists (A. and B.) were constructed, each of which contained five high P-G contingency mediators and five low P-G contingency mediators. The five mediators with high

P-G contingency in version A rhymed with the five mediators with low P-G contingency in version B, and vice versa. Therefore, though the ten target non-words were identical for both versions, the spelling outcome would be expected to be different due to the different preceding primes and mediators (see the material of experimental task in the Table 2). The two versions of prime-associate pairs were balanced structured in terms of the word frequencies in the 5 years old to 9 years old children's printed word database produced by the University of Essex (Masterson, Dixon, & Stuart, 2002), as well the association strength between primes and mediators (Nelson et al., 1998). The internal reliability of the non-words dictation task in the present sample was Cronbach's α = .406. This relative low reliability is one of the limitations in the present study and will be further discussed in the following section.

Table 2

Phonetic Representation of the Non-words in the Present Experimental Task

Target Non-words		High P-G Contingency				Low P-G Contingency		
		P	M	S		P	M	S
/zɔ:k/	A	knife	Fork	zork	B	Speak	talk	zalk
/zɔt/		cold	hot	zot		Where	what	zat
/fli:n/		tidy	clean	flean		Yellow	green	fleen
/gu:/		sky	blue	gue		Sock	shoe	goe
/pləu/		rain	snow	plow		Foot	toe	ploe
/sə:t/	B	pain	hurt	surt	A	Dress	skirt	sirt
/zʌn/		daughter	son	zon		Moon	sun	zun
/petə/		stamp	letter	petter		Coat	sweater	peater
/mɔiz/		loud	noise	moise		Girls	boys	moys
/zait/		black	white	zite		Day	night	zight

Note. P-G = Phoneme-to-Grapheme; P = Prime; M = Mediator; S = Spelling

Standardized tasks. In addition to the experimental English task, the overall language proficiency on listening comprehension and sentence reading for all participants were tested by using the Group Reading Assessment and Diagnostic Evaluation (GRADE; Williams, 2001). GRADE was chosen in the present study because of its high reliability and validity in testing early English skills of children. Considering the apparent discrepancy in language levels

between the native speakers and the second language learners, it is reasonable to use a lower level test material. Therefore, the subtests of Sentence Comprehension and Listening Comprehension at level 2 were administrated to all the participants in a group setting. The Word Reading subtest evaluates children's reading by requiring them to choose one word out of four choices that best completes the sentence with a comfortable context-fit in. The Spearman-Brown split-half reliability of this test in the present sample was r = .83. The Listening Comprehension subtest assesses children's overall phonological processing. The children are asked to circle one picture out of four choices that best describes the short sentence they just heard. The Spearman-Brown split-half reliability of this test in the present sample was r = .63.

Procedure

Research design. This study used a mixed design involving both between-subject and within-subject measures.

Between-Subject. In order to avoid the extraneous priming effects on the production of non-words, the present study adopted a complete between-subject 2 (city: Beijing vs. Montreal) x 3 (Condition: Free spelling vs. Primed 1 vs. Primed 2) design. Each participant could only be in one of the three conditions, and went through the experimental test with the same ten target non-words, and the standardized test. Without knowing any information about the teachers or the students, I randomly assigned the participants from both cities to one of the three conditions at a classroom level. This allocation results is listed in Table 3.

Within-Subject. The potential variance within subject was also taken into consideration for the present study. As a way of dealing with this issue, each participant in the primed condition was given both the high P-G contingency spelling task and low P-G contingency spelling task. Therefore, every participant would have two ultimate scores, one is the total expected target high P-G vowel spelling patterns on the five items with high P-G contingency mediators, the other is the total expected target low P-G vowel spelling patterns on the five items with low P-G contingency mediators. The score range of them is from 0 to 5.

Table 3

The Number of Participants in Each Group

City	Unprimed	Primed 1	Primed 2	Total
Beijing	19	17	22	58
Montreal	13	19	13	45
Total	32	36	35	103

Conditions. All the tests (experimental task and standardized test) were administrated to children in a group setting during two sessions. They received the same standardized test. The listening material in the standardized listening comprehension test was presented by a Montreal English native speaker through a tape-recording. The experimental task varied through the three conditions.

Condition 1: Unprimed group (Free Spelling). The ten target non-words spelling without any preceding primes were administered to the unprimed group participants. The children were given clear instructions in Chinese three times

before they had the test in order to eliminate any confusion. Each non-word was repeated twice through an audio tape which was recorded by the same Montreal English native speaker who made the standardized listening material.

The detailed instruction was the following: "Now you will hear ten nonsense words, by which I mean I made up by myself. Just try your best to give me the most plausible spelling you can think of. There is no unique correct answer, so no need to worry about that. Each non-word you will hear twice.

Ok, now, number 1, please spelling the non-word /zɔːk/,……"

Condition 2 and 3: Experimental group (Primed 1 and Primed 2). The two versions of prime-mediator lists (A and B) were given to Primed 1 group and Primed 2 group, separately. They were asked to spell the same ten target non-words as the unprimed group, but a prime was positioned immediately before each non-word. As mentioned before, these two versions of primed non-words spelling were constructed only with the difference in the identities of primes and mediators. The clear instruction was clarified to the participants three times in Chinese until no more questions showed up. Each non-word was repeated twice through the tape which was recorded by the same Montreal English native speaker.

The detailed instruction was the following: "Now you will hear ten sets of words. For each set of words, the first one is a real word, by which I mean they have real meaning. For example: apple. Every time after a real word, you will hear a nonsense word, by which I mean that I made it up by myself. So all you need to do is to carefully listen to the real word but without any spelling, then

please pay attention to the following non-word, this time try your best to give me a plausible spelling that you can think of for this non-word. Note that there is no unique correct answer, so no need to worry about that. Each word set you will hear twice.

Ok, number 1, the real word is knife, now please spell the non-word /zɔːk/,……"

All the participants received the experimental measures, the listening comprehension test, and then the sentence reading test in this fixed order. These tests took approximately 20 minutes, 10 minutes, and 10 minutes, respectively.

Results

Preliminary Data Analyses

Due to the different primes involved in the two experimental groups, two separate comparisons between the unprimed group and one of the experimental group (Unprimed vs. primed 1; Unprimed vs. primed 2) were analyzed in the present study.

For the two comparisons, all the data were first screened the deviation from normality. The descriptive analysis showed that the two measures on non-words spelling performance (total high P-G contingency spelling and total low P-G contingency spelling) were within an acceptable distribution, *skewness* < 2. Additionally, the preliminary analysis showed the absence of multicollinearity and singularity, which met the assumptions for running multivariate analysis. Then the missing data was well treated by multiple imputations. There is no

missing value on the two dependent variables for the comparison between unprimed and primed 1group; whereas the missing data on the two dependent variables accounts for 10.4% of the total data for the comparison between groups of unprimed and primed 2. It is confirmed by using SPSS missing data analysis that the data in the comparisons between unprimed group and the two primed groups were all missing completely at random (MCAR), $\chi^2(6) = 2.746$, $p = .840$, ns; $\chi^2(6) = 3.840$, $p = .698$, *ns*, for the two comparisons separately. Thus the Expectancy Maximization (EM) procedure was applied to dealing with the missing data by providing five iterations. The last (the 5th) imputed value was used in the present study. Lastly, the outliers was identified by using Mahalanobis distance, $\chi^2(2) = 13.816$, $p = .001$, to serve the purpose of running multivariate analysis. Through careful screening of the raw scores, it was concluded that these outliers are not invalid cases but extremes. Therefore, they cannot be simply removed from the complete database; their extreme raw scores are replaced by the nearest score within acceptable range (the value of Mahalanobis distance < 13.816). Therefore, in the present study, the final results are reported with the complete dataset where the outliers are well modified.

Preliminary MANOVA: Examining the reading and listening level of all participants. In addition to the regular cleaning data procedure, a preliminary MANOVA was run for examining the reading and listening level among all the participants. The descriptive information is showed in Table 4. For the three main research questions, we are only interested to examine the relationship between

two dependent variables (non-words spelling performance on high and low P-G contingency vowel patterns) and 3 independent variables (P-G Contingency in research question 1, Condition in research question 2, and City x Condition in research question 3). The other potential factors that could influence their performance on non-words spelling task should be controlled and partied from the present analysis. According to the previous findings, the strong relationship between reading and spelling should be taken into consideration. Therefore, all the participants' reading and listening comprehension skills were examined. An appropriate covariate mode is needed for the main analysis if there are significant discrepancies in reading and listening tasks.

For this preliminary MONOVA, the reading and listening performance are two dependent variables, and city and condition are two independent variables. It is showed that there are main City effect, main Condition effect, and City x Condition interaction effects in the reading and listening performance among all the participants. However, since the Box's test of equality of covariance matrices revealed a violation to MANOVA's assumption, Box's M = 84.870, $F(15, 33382.753) = 5.347$, $p < .001$, the interpretation of the result should be dealt with caution.

Table 5 showed that there are significant difference between Beijing children and Montreal children on both measures, Wilks' $\lambda = .67$, $F(1, 84) = 21.08$, $p < .001$, and the significant discrepancy across conditions, Wilks' $\lambda = .87$, $F(4,$

168) = 2.96, p = .022. The interaction effect is also observed, Wilks' λ = .81, F(4, 192) = 4.55, p = .002.

Roy-Bargmann Stepdown Analysis was conducted to carefully examine the difference in two dependent variables, and the results showed in Table 6. Analysis of Variance (ANOVA) on sentence reading revealed that there are significant City difference, F(1, 87) = 40.09, p < .001. It accounts for 31.5% of variance in predicting the participants' performance on sentence reading test. The Montreal participants outperformed their peers in Beijing by nearly two stanine, $Mean_{montreal}$ = 3.44, $Mean_{Beijing}$ = 1.53. Then there is also significant Condition difference, F(2, 87) = 6.52, p =.002, which accounts for 13% of the variance in predicting sentence reading outcome. The Post Hoc Bonferroni test on groups (in Table 7) showed that only the free spelling group scored significantly higher than the primed 2 group, $Mean_{unprimed}$ = 3.26, $Mean_{primed\ 2}$ = 2.11. Lastly, a significant interaction effect was also detected, F(2, 87) = 4.72, p = .011, to which 9.8% of variance in on sentence reading is attributed. A second ANCOVA on listening comprehension was run after controlling for the variance shared by sentence reading measure. The result showed that there is no longer any City effect or Condition effect. However, the City x Condition interaction effect was still salient. F(2, 84) = 5.41, p = .006.

Given the aforementioned strong correlation between non-words spelling performance and reading skills, as well as the significant difference displayed on sentence reading and listening comprehension across cities and conditions in the

present study, it requires a well control on the baseline of English reading knowledge and listening comprehension score for all the participants. Therefore, the Repeated MANCOVA with English reading and listening baseline as covariates were used in the main analyses of the present study.

Table 4

Mean of Sentence Reading and Listening Comprehension Across Cities and Conditions

Variables	City	Unprimed		Primed 1		Primed 2		Total	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Sentence_	Beijing	1.74	1.15	1.71	.92	1.14	.47	1.51	.92
Stanine	Montreal	4.77	2.05	2.47	1.87	3.08	1.93	3.49	2.17
	Total	2.94	2.19	2.16	1.57	1.97	1.64		
Listening	Beijing	2.21	1.40	2.59	1.37	1.27	.55	2.04	1.30
_Stanine	Montreal	3.69	2.25	1.95	1.72	3.23	2.09	2.87	2.00
	Total	2.81	1.94	2.23	1.26	2.14	1.75		

Table 5

Multivariate Analysis of City and Condition on Sentence Reading and Listening Comprehension

Effect	Value	*F*	df	Error df	Sig.	Partial Eta Squared
City	.666	21.084	2	84	.000	.334
Condition	.873	2.955	4	168	.022	.066
City x Condition	.814	4.550	4	168	.002	.098

Significant at α= .05 level

Table 6

Univariate Analysis of City and Condition on Sentence Reading and Listening Comprehension

Source	Dependent Variable	df	F	Sig.	Partial Eta Squared
City	Sentence Stanine	1	44.036	.000	.315
Condition	Sentence Stanine	2	6.899	.002	.130
City x Condition	Sentence Stanine	2	5.187	.011	.098
	Listening Stanine	2	4.338	.006	.114

Significant at α= .05 level

Table 7

Post-Hoc Mean Comparison of Condition on Sentence Reading: Bonferroni

Variables	(I)Group	(J)Group	Mean Difference (I-J)	Std. Error	Sig.
Sentence_Stanine	Unprimed	Primed 1	.84	.37	.075
		Primed 2	.97	.38	.039
	Primed 1	Primed 2	.13	.38	1.000

Significant at α= .05 level

Main Analysis: Significant results in the performance on nonword spelling

Three research questions are examined in the present study, and all of them could be tested with the Repeated MANCOVA analysis. Each participant in the primed condition was given both the high P-G contingency spelling task and

low P-G contingency spelling task, so that the P-G contingency effect is the within-subject factor. Also note that in order to eliminate the potential strong preceding prime influence, which has been found in the previous literature, the present study assigned three different primes to three groups with different participants in both Beijing and Montreal. As a result, the Condition effect and the City effect are complete between-subject factors. Additionally, the preliminary MANOVA showed a significant difference in sentence reading and listening comprehension across cities and conditions, thus it certainly needs to take the sentence reading and listening comprehension scores as covariates for the purpose of controlling for the shared variance in the two standardized tests for all the participants. For the reason explained above, Repeated MANCOVA was chosen to analyze the present data.

More precisely, due to the different primes received by the two primed groups, two independent comparisons between the unprimed group with one of the primed group were analyzed by using two separate Mixed Design MANCOVA: 2(Condition: Primed (1 or 2) vs. Unprimed) x 2 (City: Beijing vs. Montreal) MANCOVA (covariate the sentence reading and listening comprehension measures) with repeated measures on 2 word sets (P-G Contingency: High P-G Contingency vs. Low P-G Contingency).

Assumption. The non-significant result showed in Box's Test of equality of covariance confirmed the assumption being met in both repeated MANCOVA (unprimed vs. Primed1, unprimed vs. primed 2) has been met. *Box's M* = 21.884,

F(9, 31101.909), *p* = .015, *ns*, and *Box's M* = 22.120, *F*(9, 24092.473) = 2.304, *p* = .014, *ns*, respectively.

Research question 1: Overall, if the ESL children will be sensitive to the phoneme-to-grapheme contingency in English non-words vowel spelling (Contingency effect).

The Table 8 showed that in the first comparison (unprimed vs. primed 1), the P-G contingency plays a significant role in non-words spelling performance for ESL children, *F*(1, 62) = 18.307, *p* < .001. It contributes 22.8% of variance in non-words spelling results. All the children were more likely to produce the high P-G contingency vowel pattern in non-words spelling than low contingency ones, $Mean_{high}$ = .96, $Mean_{low}$ = .33. Specifically, there is significant P-G Contingency x City effect, *F*(1, 62) = 5.509, *p* = .022, which accounted for a substantial, 8.2% of the variance in non-words spelling. The descriptive data in table 9 showed that Beijing children performed lower than the Montreal participants in producing high P-G contingency non-words vowel patterns, $Mean_{Beijing}$ = .76, $Mean_{montreal}$ = 1.16; whereas for the production of low P-G contingency non-words, Beijing children showed a slight higher tendency than their Montreal peers, $Mean_{Beijing}$ = .42, $Mean_{montreal}$ = .23. This interaction effect indicated that the Montreal participants would more apply P-G contingency in their non-words vowel spelling task.

Table 8

Within-Subject Effects in Repeated Multivariate Analysis on Non-words Vowel Spelling Performance between Unprimed Group and Primed 1 Group

Effect	Value	*F*	df	Error df	Sig.	Partial Eta Squared
P-G	.772	18.307	1	62	.000	.228
P-G x Sentence Stanine	.988	.773	1	62	.383	.012
P-G x Listening Stanine	.988	.773	1	62	.383	.012
P-G x City	.918	5.509	1	62	.020	.084
P-G x City x Condition	.987	.842	1	62	.362	.013

Note: P-G = P-G Contingency

Table 9

Estimated Marginal Means of the Significant Effects

Effect			Descriptive data		After controlling sentence reading	
			Mean	SD	Mean	Std. Error
P-G		High P-G	.912	.893	.960	.110
		Low P-G	.338	.563	.327	.066
P-G x City	Beijing	High P-G	.722	.815	.761	.161
		Low P-G	.306	.525	.423	.096
	Montreal	High P-G	1.125	.942	1.159	.181
		Low P-G	.375	.609	.231	.108

Note: P-G = P-G Contingency

Table 10 shows that in the second comparison (unprimed vs. primed 2), similar to the finding in the first comparison, P-G contingency significantly predicted the performance of non-words spelling in ESL children, $F(1, 59) = 27.088$, $p < .001$. This time it contributes to an even bigger variance, 31.5%, in non-words spelling results. Results replicate those found in the first comparison (unprimed condition vs. primed 1), that the children were more likely to produce the high P-G contingency vowel pattern in non-words spelling than low contingency ones, $Mean_{high} = 1.40$, $Mean_{low} = .27$. Furthermore, the significant P-G Contingency x City effect showed as well, $F(1, 59) = 10.507$, $p = .002$, and it accounted for 15.1% of the variance in non-word vowel spelling. The descriptive

data showed in the table 11 again revealed the same interaction pattern with previous one, that Beijing children performed lower than the Montreal participants in producing high P-G contingency non-words vowel patterns, $Mean_{Beijing} = .92$, $Mean_{montreal} = 1.88$; whereas almost equally performance on producing the low P-G contingency vowel pattern in non-words spelling across cities, $Mean_{Beijing} = .28$, $Mean_{montreal} = .27$.

Table 10

Within-Subject Effects in Repeated Multivariate Analysis on Non-words Vowel Spelling Performance between Unprimed Group and Primed 2 Group

Effect	Value	*F*	df	Error df	Sig.	Partial Eta Squared
P-G	.685	27.088	1	59	.000	.315
P-G x Sentence Stanine	1.000	.021	1	59	.884	.000
P-G x Listening Stanine	.981	1.119	1	59	.294	.019
P-G x City	.849	10.507	1	59	.002	.151
P-G x City x Condition	.992	.447	1	59	.506	.008

Note: P-G = P-G Contingency

Table 11

Estimated Marginal Means of the Significant Effects

Effect			Descriptive data		After controlling sentence reading	
			Mean	SD	Mean	Std. Error
P-G		High P-G	1.308	1.014	1.401	.105
		Low P-G	.277	.484	.275	.052
P G x City	Beijing	High P-G	.821	.721	.919	.150
		Low P-G	.128	.339	.279	.070
	Montreal	High P-G	2.039	.958	1.882	.195
		Low P-G	.500	.583	.267	.090

Note: P-G = P-G Contingency

Research question 2. Is the sub-lexical spelling route influenced by lexical semantic information in ESL participants when they complete non-words spelling task. Precisely, in the present study, the possibility of interactive spelling routes for ESL children will be examined through testing the associative priming effect on non-words vowel spelling task (Contingency x Condition effect).

Table 12 shows that there is no significant condition effect in two comparisons. However, there was a Condition x P-G Contingency effect in the first comparison, $F(1, 62) = 5.669$, $p = .020$. It accounted for a moderate variance, 8.4%, in non-words vowel spelling. According to the descriptive data showed in the table 13, the children in the unprimed condition were more willingly to

produce high P-G contingency than those in primed condition, $Mean_{unprimed}$ = 1.16, $Mean_{primed\ 1}$ = .76; in contrast to almost equal performance on producing the low P-G contingency vowel patterns in non-words spelling across conditions, $Mean_{unprimed}$ = .27, $Mean_{primed\ 1}$ = .39. This Condition x P-G Contingency effect is no longer showing any significant difference in the second comparison.

Table 12

Condition Effect on Non-words Vowel Spelling Performance between Unprimed Group and Two Primed Group

Comparison	Source	df	df error	F	Sig.	Partial Eta Squared
Unprimed vs. Primed 1						
	Condition	1	62	.829	.366	.013
	Condition x P-G	1	62	5.669	.020	.084
Unprimed vs. Primed 2						
	Condition	1	59	2.422	.125	.039
	Condition x P-G	1	59	.005	.946	.000

Note: P-G = P-G Contingency

Table 13

Estimated Marginal Means of the Significant Effects

Effect			Descriptive data		After controlling sentence reading	
			Mean	SD	Mean	Std. Error
Condition x P-G	Unprimed	High P-G	1.125	.907	1.162	.167
		Low P-G	.344	.545	.266	.100
	Primed 1	High P-G	.722	.849	.758	.151
		Low P-G	.333	.586	.388	.090

Note: P-G = P-G Contingency

Research question 3. If the second research question had been confirmed within ESL participants, then to what extent this associative effect on nonword spelling is affected by the proficiency of Chinese character knowledge (Condition x City effect).

Table 14 revealed that for the both comparison, there are no Condition x City interaction effect.

Table 14

City x Condition Effects in Repeated Multivariate Analysis on Non-words Vowel Spelling Performance between Unprimed Group and Two Primed Group

Comparison	Source	df	df error	F	Sig.	Partial Eta Squared
Unprimed vs. Primed 1	City x Condition	1	62	.167	.684	.003
Unprimed vs. Primed 2	City x Condition	1	59	2.262	.138	.037

Discussion and Conclusion

In conclusion, the research questions addressed in the present study are answered. Overall, participants are significantly more likely to spell the non-word vowels by applying the weight of phoneme-to-grapheme contingency (Higher contingency > low contingency). There is consistent significant phoneme-to-grapheme Contingency x City effect across two comparisons. The children in Montreal were much more likely to spell the non-words by following the P-G contingency compared to their Beijing peers, regardless which condition they were in. In terms of the P-G Contingency x Condition effect, it is only shown in the comparison between unprimed group and primed 1 group, which indicates a negative influence on non-words production instead of the expected facilitating effect. There is a trend that the primes confused children thus affecting their performance on spelling tasks and reducing their expected responses. Furthermore,

there is consistently no main effect across conditions in the present study, which indicates that the associative effect was not evident in the present data. However, this result should be interpreted carefully, since all the measures, especially the experimental task, were designed based on the database in North American context. The degree to which these databases can be reasonably applied to ESL students with a Chinese background is still unknown. Finally, there was also no City and Condition interaction effect. Yet, the result here should be interpreted with caution due to the limitations in sampling of the current study. As stated in the following limitations section, in order to confirm the findings revealed in the present study with more confidence, a more well-designed study is needed for future research.

The higher production of the non-words spelling with high contingency than those with low contingency in all participants suggested two points, 1) ESL young learners somehow develop a sensitivity towards the vowel spelling pattern with a high P-G contingency, and 2) this P-G contingency contributes meaningfully to ESL learners' sub-lexical spelling process. This result is consistent with the one found in native speaking populations by Barry and Seymour (1988), and extends it to ESL samples. Furthermore, though this application of P-G contingency in the orthographic choice of a vowel patterns in non-words spelling task is independent of the participants' English proficiency and their ESL status, the extent to how it is applied varies considerably between different cities. The significant "City x P-G Contingency" effect showed that

Montreal children spelled better than their Beijing peers for high contingency spelling patterns. It indicated that Montreal participants are more sensitive to high contingency spelling patterns and thus more proficient in applying P-G mapping. However, the children from both cities failed to show significant difference in the vowel production with low contingency items. This result should be interpreted with caution, as all the participants scored less than .50 out of 5 in the low contingency spelling production, indicating low spelling ability. No difference among these extreme low scores could possibly be due to a floor effect. The low contingency vowel spelling task was often too difficult for them to spell out.

Two arguments could be put forward to explain the discrepancy in the sensitive to high contingency vowel spelling between two cities. First, previous research has shown that the ability to exert the phonologically plausible orthographical choice requires highly flexible manipulation of phonemes (phonological awareness), and higher spelling skills indicating higher level of words segmentation skills, which is a vital component of phonetic awareness. Therefore, in the present study, part of the reason could be attributed to the overall phonological awareness of Montreal participants being higher than the Beijing children. Though the participants' phonological awareness is not assessed directly here, it could possibly be inferred from the standardized tests used in this study. Ehri (1987, 2000), Morris and Perney (1984) revealed a close relationship between spelling and reading especially in the early years of literacy acquisition. They found .86, a considerable high correlation, between spelling and reading in

the first grade. This strong relationship could reflect a mutual support developmentally between reading and spelling. In this two-way development, phonological awareness is proven to be the key mediator. Bowey and Underwood (1996) found that children with higher proficiency in word-level reading would be more likely to use orthographic rime in non-word reading correspondences. Consequently, the significant higher level of sentence reading in the Montreal sample compared to the Beijing sample indicated their different overall phonological awareness level. What is more, the result also supports the argument that phonological awareness is a learned trait as the children in Montreal have had benefited more from experience with English in this bilingual context.

Second, the learning context could be another significant factor contributing to this result. If so, it also provides a potential insight into the most effective ways of teaching L2. As shown in the demographic information of the participants, Beijing children were exposed to English more frequently (37.9% of children devoting more than 4 hours per week in English), and began their instruction earlier (4.26 years) than the Montreal children do (spending 2.68 years in English learning and 4.4% of them devoting more than 4 hours per week to English). However, they performed significantly less well than their Montreal counterparts. This indicates that the quantity of language instruction per se does not uniquely predict learning outcomes, and suggests that other elements, such as the quality of instruction or the cultural environment, might be more crucial to this case. Though it might be difficult to infer how distinct teaching method lead

to diverse learning outcome from present study, numerous educational research studies targeting effective learning have put an effort on clarifying the relationship between teaching and learning among L2 learners (Doughty, 1991; Norris & Ortega, 2001; Pica, 1994). Proper materials, active teaching strategies, and effective assessment are proved to be the key elements related to satisfying learning outcome. Future research is needed to explore the role of different instructional styles play in observed students' academic performance.

In the present study, one other aspect of the learning context deserves attention. Due to the fact that Montreal is a bilingual city, children raised in the city receive a certain level of dual language instruction from their early school years. They also receive English immersion when they are in some public places, such as restaurants and shops. However in China, even though all the participants have access to English instruction in the classroom, they are living in a purely Chinese environment with limited English resources in society at large.

Additionally, the potential French influence on the English performance for the Montreal children should not be overlooked in the present study. As argued before, French and English both belong to alphabetic languages, thus they share some linguistic similarities, for example the P-G correspondence at the phoneme level. It is speculated that the similarity of fundamental structures of these two languages provides the Montreal children in the current study with a better understanding of English acquisition. From this point of view, a comprehensive insight towards L2 instruction that factors from inside (linguistic

characteristics) and outside (learning context influence) is needed to further establish.

In the present study, for comparison 1 (unprimed vs. primed 1), the children in the primed condition spelled less expected vowel patterns than their peers in unprimed condition. In terms of the second comparison (unprimed vs. primed 2), there is no significant difference between two conditions. The inconsistent results from two comparisons indicate no associative priming effect in present sample. Consequently, it fails to support the interactive effect between the lexical and sub-lexical spelling route in ESL children. In contrast to the facilitating effect from the associative priming revealed by Seymour and Dargie (1990), no facilitation and sometimes interference effects were revealed here. This may indicate a relative independence of the two routes embedded in young ESL language system.

This failure and even inhibitory effect of the associative priming could be explained in two possible ways. One point argued with the dual route assumption is that the semantic-lexical route and sub-lexical route involved in L2 spelling are independent from each other for the present participants. However, it is still difficult to conclude the independency of the semantic-lexical and sub-lexical routes unless future research on well-developed ESL learners can establish this. It would be reasonable to suggest that this independence of the two spelling processes could be at least true for the young, early ESL learners. The other possible explanation involves a further analysis of this experimental task. The

completion of this task actually demands a chain of activations. It requires that the phonological representation of the prime activates its meaning, and then the meaning of the prime activates the meaning and orthographical representation of the associated mediator. The failure in any step of the aforementioned chain-process could lead to failure to find an associative priming effect. Seymour and Dargie's study (1990) has verified the success in the chain-activation in native speakers sample. If so, then why is it not working for the ESL children in the present study?

In terms of the semantic presentation, Kroll and Stewart (1994), proposed a model of bilingual lexico-semantic organization. They claim that, unlike L1, L2 words do not directly link with their semantics, but instead can be derived indirectly from the L1 equivalents. The strong, form-to-meaning link in L2 can only be achieved by high proficiency in L2. The participants in the present study are beginner learners of English. Their limited L2 knowledge is too weak to build upon L2 vocabulary systems independent of the L1. Therefore, the completion of this associative priming task demands several transfers from L1 to L2. The possible process involved could be that the phonological representation needs to connected to its L1 equivalent meaning, within the L1 semantic memory, it activates the L1 semantic association, and then this L1 semantic association leads to the production of the target mediator in L2. The increase in workload and their relative low English proficiency (revealed by low scores in sentence reading and listening comprehension performance) might hinder their performance on

associative priming effect. Surprisingly, the preceded prime confused participants and blocked the process of applying the P-G contingency resulting in the inhibitory effect in the present study.

Alternatively, the semantic priming effects are not transferable from Chinese to English. As a result, the degree of Chinese knowledge proficiency would not be a factor influencing their spelling performance. Due to the distinct writing scripts, the prerequisite skills for semantic activation in Chinese character writing might not be able to transfer to the spelling process of English non-words. However, there is also a possibility that the transfer does exist, the limitations in the present study prevent showing these differences. Either the participants' poor English knowledge might hinder the significant difference occurring in their spelling performance on the task, or the Chinese knowledge of these children is not stable and well developed enough to show their strength on the target task.

In summary, the present study suggested that the P-G contingency is also applicable for young ESL learners. The overall phonological awareness will draw differences on the competency of employing the P-G contingency. The expected semantic priming effect was not detected in the present study. It indicates that the semantic-lexical and sub-lexical English spelling processes are not as interactive as argued in Seymour and Dargie's study, at least not for young ESL children. Further research is needed to explore semantic activation transfer from L1 to L2 in reading and spelling.

Contribution, limitations and implications

This is the first study to attempt to examine associative priming in English non-words spelling among ESL young learners. The data was collected in two cities, Beijing and Montreal in order to sufficiently represent Chinese-English bilingualism worldwide. This data adds to our understanding of contingency effects by extending research to the ESL samples and aids in the development of the broader view to understanding the nature of mechanisms underlying sub-lexical spelling processes in L1 and L2 contexts.

Nevertheless, there are several limitations in the present study. First of all, due to limited resources, the sampling of this study is randomized at a classroom not pupil-level. This could lead to bias when interpreting the final results. Secondly, in terms of the measurements which were used, there are also some arguable points. One is that all the measures, including the experimental task and standardized tests, were produced in a North American context. The differences in learning context between China and North America should be considered more carefully. In particular, the experimental task was generated mainly from the word frequency and association databases which are heavily based on the language environment in North America. Furthermore, only the listening and sentence comprehension sections of the GRADE test were administrated in the present study. There are no measures to control for the other potential interference factors, such as the level of cognitive skills underlying spelling, phoneme awareness, letter sound knowledge, and oral language skill. Additionally, the relative low

reliability of the experimental task used in the present study (Cronbach's $\alpha = .406$) suggests that caution should be used in any interpretation involving this task. Lastly, the present study only targets participants with both Chinese and English language knowledge and due to the practical limitations failed to include control group of young, native English speakers. The difference between Anglophone children and ESL children has still not been explored.

In terms of implications and future directions, future research should involve a more pupil-level randomized sampling, appropriate experimental materials sensitive to local influence, adequate reliability of the measures and more relevant sub-cognitive tests for controlling the shared variance. Finally, studies should continue to explore linguistic transfer and underlying processing mechanisms between Chinese and English speakers, also a developmental approach examining whether children will show the associative effect as they age.

References

Barry, C., & De Bastiani, P. (1997). Lexical priming of nonword spelling in the regular orthography of Italian. *Reading and Writing, 9*(5-6), 499-517.

Barry, C., & Seymour, P. H. K. (1988). Lexical priming and sound-to-spelling contingency effects in nonword spelling. *The Quarterly Journal of Experimental Psychology Section A, 40*(1), 5-40. doi: 10.1080/14640748808402280

Bates, T. C. (2006). Genes for reading and spelling. *London Review of Education, 4*(1), 31-47. doi: 10.1080/13603110600574413

Bates, T. C., Castles, A., Luciano, M., Wright, M. J., Coltheart, M., & Martin, N. G. (2007). Genetic and environmental bases of reading and spelling: A unified genetic dual route model. *Reading and Writing, 20*(1-2), 147-171. doi: 10.1007/s11145-006-9022-1

Bowey, J. A., & Underwood, N. (1996). Further evidence that orthographic rime usage in nonword reading increases with word-level reading proficiency. *Journal of Experimental Child Psychology, 63*(3), 526-562.

Campbell, R. (1983). Writing nonwords to dictation. *Brain and Language, 19*(1), 153-178.

Campbell, R. (1985). When children write nonwords to dictation. *Journal of Experimental Child Psychology, 40*(1), 133-151.

Castles, A., Bates, T. C., & Coltheart, M. (2006). John Marshall and the developmental dyslexias. *Aphasiology, 20*(9), 871-892.

Chen, C. (2006). A quarte of Chinese study English. from http://opinion.people.com.cn/GB/35560/4241821.html

Chen, H. C., & Tsoi, K. C. (1990). Symbol-word interference in Chinese and English. *Acta Psychologica, 75*(2), 123-138.

Cheng, H. W., & Caldwell-Harris, C. (2010). *Orthography shapes semantic and phonological activation in reading.* Paper presented at the th Annual Meeting of the Berkeley Linguistics Society. University of California, Berkeley, USA.

Chinese College, Jinan University, China. (2007). Zhongwen. 2rd. from http://www.hwjyw.com/textbooks/downloads/zhongwen/

Coltheart, M., & Byng, S. (1989). A treatment for surface dyslexia. In X. Seron & G. Deloche (Eds.), *Cognitive approaches in neuropsychological rehabilitation* (pp. 159-174). London: Erlbaum.

Coltheart, M., Curtis, B., Atkins, P., & Haller, M. (1993). Models of reading aloud: Dual-route and parallel distributed processing approaches. *Exploring Cognition: Damaged Brains and Neural Nets: Readings in Cognitive Neuropsychology and Connnectionist Modelling, 100*(4), 367.

Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: a dual route cascaded model of visual word recognition and reading aloud. *Psychological review, 108*(1), 204.

Cotelli, M., Abutalebi, J., Zorzi, M., & Cappa, S. F. (2003). Vowels in the buffer: a case study of acquired dysgraphia with selective vowel substitutions. *Cogn Neuropsychol, 20*(2), 99-114. doi: 10.1080/02643290244000158

Cuetos, F. (1993). Writing processes in a shallow orthography. *Reading and Writing, 5*(1), 17-28.

Cui, L., & Peng, F. L. (2010). Yuwen. 19th. from http://www.pep.com.cn/xiaoyu/jiaoshi/tbjx/kbjiaocai/xy5s/

Doughty, C. (1991). Second language instruction does make a difference. *Studies in Second Language Acquisition, 13*(04), 431-469.

Ehri, L. C. (1987). Learning to read and spell words. *Journal of Literacy Research, 19*(1), 5-31.

Ehri, L. C. (2000). Learning to read and learning to spell: Two sides of a coin. *Topics in Language Disorders, 20*(3), 19.

Feldman, L. B., & Siok, W. W. T. (1999). Semantic radicals contribute to the visual identification of Chinese characters. *Journal of Memory and Language, 40*(4), 559-576.

Folk, J. R., & Rapp, B. (2004). Interaction of lexical and sublexical information in spelling: Evidence from nonword priming. *Applied Psycholinguistics, 25*(04), 565-585.

Folk, J. R., Rapp, B., & Goldrick, M. (2002). The interaction of lexical and sublexical information in spelling: What's the point? *Cognitive Neuropsychology, 19*(7), 653-671.

Funnell, E., & Davison, M. (1989). Lexical capture: A developmental disorder of reading and spelling. *The Quarterly Journal of Experimental Psychology Section A, 41*(3), 471-487. doi: 10.1080/14640748908402377

Geva, E., & Siegel, L. S. (2000). Orthographic and cognitive factors in the concurrent development of basic reading skills in two languages. *Reading and Writing, 12*(1-2), 1-30.

Gottardo, A., Yan, B., Siegel, L. S., & Wade-Woolley, L. (2001). Factors related to English reading performance in children with Chinese as a first language: More evidence of cross-language transfer of phonological processing. *Journal of Educational Psychology, 93*(3), 530-542.

Harm, M. W., & Seidenberg, M. S. (1999). Phonology, reading acquisition, and dyslexia: Insights from connectionist models. *PSYCHOLOGICAL REVIEW-NEW YORK-, 106*, 491-528.

Hillis, A. E., & Caramazza, A. (1991). Mechanisms for accessing lexical representations for output: Evidence from a category-specific semantic deficit. *Brain and language, 40*(1), 106-144.

Hillis, A. E., Rapp, B. C., & Caramazza, A. (1999). When a rose is a rose in speech but a tulip in writing. *Cortex, 35*(3), 337-356.

Holm, A., & Dodd, B. (1996). The effect of first written language on the acquisition of English literacy. *Cognition, 59*(2), 119-147.

Houghton, G., & Zorzi, M. (2003). Normal and impaired spelling in a connectionist dual-route architecture. *Cogn Neuropsychol, 20*(2), 115-162. doi: 10.1080/02643290242000871

Kahn-Horwitz, J., Sparks, R. L., & Goldstein, Z. (2012). English as a foreign language spelling development: A longitudinal study. *Applied Psycholinguistics, 33*(02), 343-363.

Kang, J. S. (1993). Analysis of semantics of semantic-phonetic compound characters in modern Chinese. . In Y. Chen (Ed.), *Information analysis of usage of characters in modern Chinese* (pp. 68-83). Shanghai: Shanghai Education Publisher.

Kohnen, S., Nickels, L., Brunsdon, R., & Coltheart, M. (2008). Patterns of generalisation after treating sub-lexical spelling deficits in a child with mixed dysgraphia. *Journal of Research in Reading, 31*(1), 157-177. doi: 10.1111/j.1467-9817.2007.00366.x

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of memory and language, 33*, 149-149.

Leck, K. J., Weekes, B. S., & Chen, M. J. (1995). Visual and phonological pathways to the lexicon: Evidence from Chinese readers. *Memory & Cognition, 23*(4), 468-476.

Leong, C. K., Tan, L. H., Cheng, P. W., & Hau, K. T. (2005). Learning to read and spell English words by Chinese students. *Scientific Studies of Reading, 9*(1), 63-84.

Lipka, O., & Siegel, L. S. (2007). The development of reading skills in children with English as a second language. *Scientific Studies of Reading, 11*(2), 105-131.

Liu, Y., & Hao, J. (2005). English. from http://www.pep.com.cn/xe/

Major, R. C. (2001). Foreign accent. *Blackwell Publishing Ltd.*

Masterson, J., Dixon, M., & Stuart, M. (2002). *Printed word frequencies as read by children aged between 5 & 9*. Retrieved from: http://www.essex.ac.uk/psychology/cpwd/

McBride-Chang, C., Shu, H., Zhou, A., Wat, C. P., & Wagner, R. K. (2003). Morphological awareness uniquely predicts young children's Chinese character recognition. *Journal of Educational Psychology, 95*(4), 743-751.

McBride-Chang, C., Wagner, R. K., Muse, A., Chow, B. W., & Shu, H. (2005). The role of morphological awareness in children's vocabulary acquisition in English. *Applied Psycholinguistics, 26*(3), 415.

McBride–Chang, C., & Kail, R. V. (2002). Cross–cultural similarities in the predictors of reading acquisition. *Child development, 73*(5), 1392-1407.

Miceli, G., & Capasso, R. (2006). Spelling and dysgraphia. *Cogn Neuropsychol, 23*(1), 110-134. doi: 10.1080/02643290500202730

Miron, D., & Filip, R. P. (2012). *Portraits régionaux 2001-2010 Caractéristiques des immigrants établis au Québec et dans les régions en 2012*. Retrieved from http://www.micc.gouv.qc.ca/publications/fr/recherches-statistiques/Portraits_regionaux_2001-2010.pdf.

Morris, D., & Perney, J. (1984). Developmental spelling as a predictor of first-grade reading achievement. *The elementary school journal, 84(4),* 441-457. doi: 10.1086/461375

Morton, J. (1980). The logogen model and orthographic structure. In U. Frith (Ed.), *Cognitive processes in spelling* (pp. 117-134). New York: Academic Press.

Nelson, D. L., McEvoy, C. L., & Schreiber, T. A. (1998). The University of South Florida word association, rhyme, and word fragment norms.

Norris, John M, & Ortega, Lourdes. (2001). Does Type of Instruction Make a Difference? Substantive Findings From a Meta‐analytic Review. *Language Learning, 51*(s1), 157-213.

Perfetti, C. A., Cao, F, & Booth, J. (2013). Specialization and universals in the development of reading skill: How Chinese research informs a universal science of reading. *Scientific Studies of Reading, 17*(1), 5-21.

Pica, T. (1994). Research on Negotiation: What Does It Reveal About Second‐Language Learning Conditions, Processes, and Outcomes? *Language learning, 44*(3), 493-527.

Plaut, D. C. (1997). Structure and function in the lexical system: Insights from distributed models of word reading and lexical decision. *Language and cognitive processes, 12*(5-6), 765-806.

Plaut, D. C. (1999). A connectionist approach to word reading and acquired dyslexia: Extension to sequential processing. *Cognitive Science, 23*(4), 543-568.

Plaut, D. C. (2003). Interpreting double dissociations in connectionist networks. *Cortex, 39(1),* 138-141.

Plaut, D. C., & Booth, J. R. (2000). Individual and developmental differences in semantic priming: Empirical and computational support for a single-mechanism account of lexical processing. *Psychological review, 107*(4), 786.

Plaut, D. C., & Gonnerman, L. M. (2000). Are non-semantic morphological effects incompatible with a distributed connectionist approach to lexical processing? *Language and Cognitive Processes, 15*(4-5), 445-485.

Plaut, D. C., & Kello, C. T. (1999). The emergence of phonology from the interplay of speech comprehension and production: A distributed connectionist approach. *The emergence of language*, 381-415.

Plaut, D. C., McClelland, J. L., Seidenberg, M. S., & Patterson, K. (1996). Understanding normal and impaired word reading: computational principles in quasi-regular domains. *Psychological review, 103*(1), 56.

Pring, L., & Snowling, M. (1986). Developmental changes in word recognition: An information-processing account. *The Quarterly Journal of Experimental Psychology, 38*(3), 395-418.

Rapcsak, S. Z., Henry, M. L., Teague, S. L., Carnahan, S. D., & Beeson, P. M. (2007). Do dual-route models accurately predict reading and spelling performance in individuals with acquired alexia and agraphia? *Neuropsychologia, 45*(11), 2519-2524. doi: 10.1016/j.neuropsychologia.2007.03.019

Rapp, B., Epstein, C., & Tainturier, M. J. (2002). The integration of information across lexical and sublexical processes in spelling. *Cogn Neuropsychol, 19*(1), 1-29. doi: 10.1080/0264329014300060

Rosson, M. B. (1983). From SOFA to LOUCH: Lexical contributions to pseudoword pronunciation. *Memory & Cognition, 11*(2), 152-160.

Seymour, P. H. K., & Dargie, A. (1990). Associative priming and orthographic choice in nonword spelling. *European Journal of Cognitive Psychology, 2*(4), 395-410.

Seymour, P. H. K., & Porpodas, C. D. (1980). Lexical and nonlexical processing of spelling in developmental dyslexia. In F. U. (Ed.), *Cognitive processes in spelling* (pp. 443-474). New York: Academic Pressaa.

Tainturier, M. J., & Rapp, B. (2001). The spelling process. *The handbook of cognitive neuropsychology: What deficits reveal about the human mind*, 263-289.

Treiman, R. (1993). *Beginning to spell*: A study of first-grade children. *Oxford University Press*.

Treiman, R., & Bourassa, D. C. (2000). The development of spelling skill. *Topics in language disorders, 20*(3), 1-18.

Wang, M., & Geva, E. (2003). Spelling performance of Chinese children using English as a second language: Lexical and visual-orthographic processes. *Applied Psycholinguistics, 24*(1), 1-26.

Wang, M., Perfetti, C. A., & Liu, Y. (2005). Chinese-English biliteracy acquisition: cross-language and writing system transfer. *Cognition, 97*(1), 67-88. doi: 10.1016/j.cognition.2004.10.001

Weekes, B. S., Chen, M. J., & Lin, Y. B. (1998). Differential effects of phonological priming on Chinese character recognition. *Reading and Writing, 10*(3-5), 201-221.

Williams, K. T. (2001). *Group Reading Assessment and Diagnostic Evaluation: Teacher's scoring and interpretive manual.* Circle Pines, MN: American Guidance Service.

Yeung, P.-S., Ho, C. S.-H., Chik, P. P.-M., Lo, L.-Y., Luan, H., Chan, D. W.-O., & Chung, K. K.-H. (2011). Reading and spelling Chinese among beginning readers: What skills make a difference? *Scientific Studies of Reading, 15*(4), 285-313. doi: 10.1080/10888438.2010.482149

Young, K. (2007). Developmental stage theory of spelling: Analysis of consistency across four spelling-related activities. *Australian Journal of Language and Literacy, The, 30*(3), 203.

Zhou, Y. G. (1978). To what degree are the "phonetics" of present-day Chinese characters still phonetic. *Zhongguo Yuwen, 146*, 172-177.