Tonal bilingualsim: the case of two related Chinese dialects

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Title: Tonal bilingualism : the case of two closely related Chinese dialects
Issue Date: 2015-07-02

1 General Introduction

This thesis investigates the tonal bilingualism involving two closely related Chinese dialects, Standard Chinese (SC) and Jinan Mandarin (JM), a special type of bilingualism. It is special in that it involves (1) two tonal systems, (2) two closely related dialects, and (3) a common logographic writing system.

Focusing on the impact of these factors, this thesis revisits a series of research questions on bilingual lexical process in the context of this special type of bilingualism. Considering interlingual tonal mapping, how do native tonal bilinguals process similar tonal categories from their two tonal systems in lexical access and speech comprehension? Closely related dialects have systematic correspondence between their closely related vocabularies. Is the strength of tonal systematic correspondence in these bilinguals' lexical production affected by the tonal bilinguals' sociolinguistic and cognitive backgrounds? This type of bilingualism involves many etymologically related translation equivalents. How does the tonal similarity between these equivalents affect auditory lexical access? JM shows a significant number of tonal lexical variants. How do the JM speakers handle this tonal pattern variability and store these variants in their mental lexicon? What is the role of interlingual identity in the bilinguals' mental representation and lexical access of these variants? SC and JM use a common logographic writing system; does this affect the bilinguals' automatic visual word recognition? How do they benefit or suffer from this system compared with tonal monolinguals?

In the following sections, after an introduction to SC and JM, the three special aspects of SC-JM tonal bilingualism will be introduced one-by-one, with reviews of relevant research areas, and then brief introductions will be given to each of the main chapters.[i]

1.1 Bilingualism with two tonal systems

Standard Chinese, also frequently referred to as 'Mandarin', 'Mandarin Chinese', 'Putonghua', or just 'Chinese', is a typical tonal language which uses pitch contours to differentiate lexical meanings. It is also one of the most thoroughly examined tonal languages. To maintain consistency, I will only use the term 'Standard Chinese' (SC) in the following sections.

SC is the official language of China (since 1956). Unlike the situation of many European official languages, SC is strictly standardized in its pronunciation. SC speakers can take 'Putonghua Shuiping Ceshi (PSC)' (Putonghua Proficiency Test, since 1994) to see how close their pronunciation is to the standard. Also, SC is mandatorily used in schools within the system of Nine-Year Compulsory Education (except in some administrative units with Minority Compact Communities) and teachers of Chinese in China are required to reach Level 2A (the third highest level) in the PSC test. The national promotion of SC started early and has spread from the urban areas to the rural areas in the past few decades. As a result, most young Chinese throughout China speak SC fluently, many with SC as their first language. Educated SC speakers' accents can be extremely standard. Nevertheless, many Chinese are native bilinguals of SC and their regional Chinese dialects.

Jinan Mandarin (JM) is also a tonal Mandarin dialect spoken by a large population. As a regionally prestigious dialect, JM is spoken in Jinan, the capital of Shandong province in northern China (Qian, 1997). Most JM speakers also speak SC fluently, and the mutual intelligibility between JM and SC is high (Tang & van Heuven, 2009). With the half-century promotion of SC, the demography of bilingualism has changed from JM-dominant to SC-dominant in Jinan. Literacy education used to be carried out mostly in JM but now it is mostly in SC. Although the number of active users of JM is dropping quickly, the society of JM speakers is still relatively large and vital.

Both SC and JM are tonal. The phonological system and pronunciation of SC are standardized according to Beijing Mandarin [ii], which has four citation tones (Brotzman, 1964; Y.R. Chao, 1948; Dreher & Lee, 1968; Fu, 1924), as demonstrated in Figure 1 with examples. JM also has four citation tones (Qian, 1997; Qian & Zhu, 1998), as demonstrated in Figure 2 with examples. Like the other Chinese dialects, both SC and JM use contour tones to distinguish lexical meaning. SC has one famous tone sandhi rule: a low-rising tone (Tone 3) followed by another low-rising tone within the same prosodic phrase is realized as a high-rising tonal contour (similar to Tone2). Additionally, the rising part of the SC low-rising tone is not fully realized in many cases, including when preceding another tone and optionally in fast speech (Lee & Zee, 2003). JM tone sandhi is more complex. The rules have been under some discussion and the reported pattern is ambiguous (Qian, 1997). The details of some aspects and the corresponding causes will be introduced and investigated in the following chapters. The dominant rules assumed in this thesis are as follows:

Rising+High-falling -> Low+High-falling
Rising+High-level -> Low+High-level
Low-falling+Low-falling -> Rising+Low-falling[iii]
Rising+neutral -> Low-falling+Low
High-falling+neutral -> Rising+High
High-level+neutral -> Low+High
Low-falling+neutral -> High-level+neutral

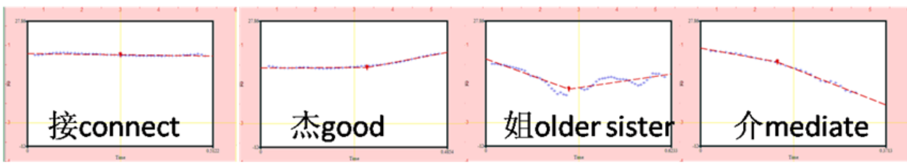

Figure 1. *Pitch contours on the rhymes of a SC tonal minimal set with the same segmental structure /tɕiɛ/ [from left to right, 1: high-level, 2: high-rising, 3: low-rising (dip); 4: falling]. It is pronounced by a young female SC native speaker with PSC 1b and plotted with a custom-made piecewise regression function in Praat (Boersma & Weenink, 2014). Examples of SC pitch contours plotted with early recordings can be found by Brotzman (1964), Dreher & Lee (1968), and Fu (1924).*

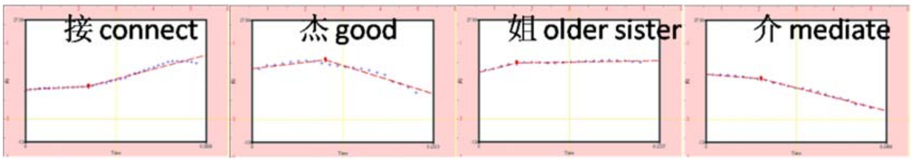

Figure 2. *Pitch contours on the rhymes of a JM tonal minimal set with the same segmental structure /tɕiɛ/*[iv] *[from left to right, 1: rising, 2: high-falling, 3: high-level; 4: low-falling], pronounced by an old male JM speaker recorded by Qian (1998), plotted with a custom-made piecewise regression function in Praat (Boersma & Weenink, 2014).*

For both JM and SC, morphemes carrying neutral tones lose the contrast of their citation tonal forms, and the F0 realization of the neutral tone varies, depending on the preceding citation tone. Nevertheless, JM neutral tone sandhi is different from the case of SC, in that JM morphemes preceding neutral tones are realized as different sandhi forms from their citation forms, while in the same position SC morphemes largely maintain the citation form.

The bilingualism of SC and JM involves two systems of lexical tones. In the following four subsections, we will review the uniqueness of tonal languages and the results of bilingual studies involving tonal languages.[v]

1.1.1 The uniqueness of tonal languages

The uniqueness of tonal language processing has been investigated extensively, especially in speech perception and lexical access.

As with speech perception, categorical perception of native tones is supported by recent neurological studies, in which the mismatch negativity (MMN) is larger across categories than within categories (Chandrasekaran, Krishnan, & Gandour, 2009; Xi, Zhang, Shu, Zhang, & Li, 2010). However, behavioral studies showed that, compared with segmental phonemes, native perception of Chinese tones is 'quasi-categorical', neither as categorical as that of consonants nor as continuous as that of vowels (Hallé, Chang, & Best, 2004). The retrieval of tonal information, compared with segmental information seems to be slower (Ye & Connine, 1999; Q. Zhang & Damian, 2009; Q. Zhang & Zhu, 2011) and involves different neuronal networks (Liang & van Heuven, 2004).

Experience with tonal languages changes tone-related perception and the corresponding neurological activities. Faced with between-category contrasts in odd-ball paradigms, tonal language speakers showed larger mismatch negativity (MMN) responses than non-tonal language speakers (Chandrasekaran, Krishnan, & Gandour, 2007; Chandrasekaran et al., 2009) to the mismatch. The tonal language speakers behave more similarly to musicians than non-musicians who do not speak a tonal language, showing a domain-general advantage (Chandrasekaran et al., 2009); Tonal language speakers have general advantage in discriminating musical tones and are less affected by pitch perturbation (Ning, Shih, & Loucks, 2014). When making a phonetic decision, tonal language speakers and non-tonal language speakers showed differences in selective attention: speakers of tonal language (SC) process consonants and tones in a combined manner, but non-tonal language (English) speakers can separate them in the process of speech perception (M. Lin & Francis, 2014). Experience with tonal language not only modifies the cortical distribution of stimulus-dependent activation (Hsieh, Gandour, Wong, & Hutchins, 2001; Krishnan, Gandour, Ananthakrishnan, & Vijayaraghavan, 2014), but also strengthens the correlation between cortical pitch response (CRP) components and pitch acceleration (Krishnan et al., 2014).

As with lexical access, lexical tones are also processed differently from segmental phonemes. The overlap of SC tones alone induced no facilitatory priming effect in implicit priming (J. Y. Chen, Chen, & Dell, 2002), differing from the classical priming effect introduced by segmental overlap. Nor does sharing both surface tones and segments cause facilitatory priming (Y. Chen, Shen, & Schiller, 2011). However, tonal sharing (tonemes or overt tonal realizations) accompanied with segmental sharing introduced phonological facilitation in two picture-word interference experiments (Nixon, Chen, & Schiller, 2014), similar to the case of segmental sharing. Lexical adaptation also seems to work similarly in tones (Mitterer, Chen, & Zhou, 2011) and consonants (McQueen, Cutler, & Norris, 2006). Moreover, eye-tracking evidence support that, in constraining activation, tonal and segmental accesses are concurrent and play comparable roles (Malins & Joanisse, 2010).

1.1.2 Perceptual learning of non-native lexical tones

Recent studies investigated the perceptual learning of non-native lexical tones. On the one hand, native experience with tonal languages interacts with the brain networks. Learning non-native tones changes the brain network (Yang, Gates, Molenaar, & Li, 2014) and strengthens the brain response to within-category tonal contrast in right STG (Zinszer, Chen, Wu, Shu, & Li, 2014). Also, individual differences in white matter pathways can predict the learning success of a tonal language (SC) (Qi, Han, Garel, San Chen, & Gabrieli, 2014).

On the other hand, experience with tonal languages influences perceptual learning of a new tonal language. It is found that, in perceptual learning, non-native tones (Cantonese lexical tones) triggered different changes in the identification and perceptual space of speakers with native tonal experience (SC) versus speakers without native tonal experience (English) (Francis, Ciocca, Ma, & Fenn, 2008). However, findings on whether L1 lexical tone experience necessarily helps the learning of L2 tonal perception are inconsistent. For instance, while Mandarin speakers showed greater advantages over English speakers in distinguishing Thai tones after training (Wayland & Guion, 2004), Hmong learners performed surprisingly worse than English learners in perceiving Chinese tones (Wang, 2006).

1.1.3 Interlingual tonal perception

Previous studies involving two tonal languages have focused on interlingual tonal perception. After early focus on the matching of lexical tone and lexical stress in non-native production (Y. R. Chao, 1980; Cheng, 1967; Cheung, 2008), research attention was drawn to tonal perception across different tonal languages (Reid et al., 2014; So & Best, 2010; Xujin Zhang, Samuel, & Liu, 2012). So and colleagues' studies focus on naïve listeners and were discussed under the Perceptual Assimilation Model (PAM) (C. T. Best, 1995) which claims that naïve listeners perceive non-native phones according to the closest L1 phonemes (if they exist). However, recent findings suggest that tonal assimilation also needs to take phonetic and even acoustic similarity into consideration (Reid et al., 2014). The other two popular models for interlingual perception are the SLM model (J. E. Flege, 1995; James Emil Flege, MacKay, & Piske, 2002), which focuses more on L2 learning, and the native-language magnet (NLM) model (Kuhl, 1991; Kuhl, Williams, Lacerda, Stevens, & Lindblom, 1992), which focuses more on perception within the L1 category. I have not found studies of interlingual tonal perception discussed under these two models. Zhang and colleagues' research showed that, although they have early and rich experience using SC, native speakers of Cantonese are clearly influenced by Cantonese when handling SC contrasts in acoustic, perceptual, and lexical processing. They were also the first to find that the tonal effects are of a similar pattern but smaller than segmental effects (Xujin Zhang et al., 2012). A recent study provided some new insights into the role of pitch in bilingual tonal perception: tonal and non-tonal language users may attend to the same pitch movements in different ways (Braun & Johnson, 2011). Despite these studies, little is known about the interlingual tonal perception of real tonal bilinguals. B. Chen reported the development of Tai-accented Chinese lexical production in child second language learners (who later become tonal bilingual adults, like a significant portion of that linguistic society) and associated his findings (including the change of tonal mapping) with macroscopic language contact and language evolution (B. Chen, 1996). Nevertheless, the mental process of interlingual tonal perception by real tonal bilinguals remains largely unknown.

The above-mentioned two sets of studies focus on naïve listeners or beginning learners of tonal languages. Real tonal bilinguals, people who already speak two tonal languages/dialects, however, receive less attention. A large number of residents in China speak SC and at least one tonal dialect or language natively, which can be another Mandarin dialect (e.g. Jinan Mandarin), a more distant Chinese dialect (e.g. Cantonese), or another tonal language spoken in China (e.g. Tai dialects spoken in southwest China[vi]). Two previous studies involving Cantonese-SC bilinguals showed some unique attributes of these tonal bilinguals in speech processing. Children who are bilingual in Cantonese and SC showed more advanced tonal awareness compared with tonally monolingual SC speaking children (X. Chen et al., 2004). Also, in a recent study, the correlation between naming performance and left inferior parietal lobule (LIPL) volume was more prominent for Mandarin-Cantonese tonal bilinguals than for Cantonese-English bilinguals (Abutalebi, Canini, Della Rosa, Green, & Weekes, 2014). Nevertheless, the relations of the two vocabularies and two tonal systems need to be taken into consideration and the role of tone in bilingual speech perception and lexical access needs more investigation. SC-JM bilingualism makes a good test case.

1.1.4 SC in bilingual studies

It is not uncommon to include tonal languages in bilingual studies. Standard Chinese, as one of the world's most widely spoken languages, was included in bilingual experiments to investigate different research questions.

For instance, proficient late SC-English bilinguals showed onset priming in English but syllabic priming in Chinese in word-naming, indicating that they use different phonological units (syllables and phonemes) to fill the metrical frame according to the language mode (Verdonschot, Nakayama, Zhang, Tamaoka, & Schiller, 2013). However, acoustic analysis of late SC-English bilinguals' English production indicates that the rhythm of the interlanguage (Chinese accented English) needs to be interpreted with both SC and English rhythmic units under consideration (H. Lin & Wang, 2008).

Consistent with the results found between other languages, the SC findings support parallel bilingual lexical activation. Researchers have found interlingual semantic priming (Keatley, Spinks, & De Gelder, 1994), translation priming (H.-C. Chen & Ng, 1989), and cross-language identity effects (Taomei Guo & Peng, 2006) between SC and English. Also, late SC-English bilinguals are sensitive to concealed relations of Chinese characters when performing lexical comprehension tasks in English, indicating unconscious translation to the native language (Thierry & Wu, 2004; Y.J. Wu & G. Thierry, 2010; Yan Jing Wu & Guillaume Thierry, 2010; Y. J. Wu & Thierry, 2011, 2012).

As with bilingual language and executive control, SC learners of English were tested for the neural correlates of global and local language-switching costs (T. Guo, Liu, Misra, & Kroll, 2011; Prior & Gollan, 2011). Comparing SC-English bilinguals with English monolinguals, the bilinguals showed executive advantages (Tao, Marzecová, Taft, Asanowicz, & Wodniecka, 2011), as has been found with bilinguals of other languages (Bialystok, Craik, & Luk, 2008). Moreover, in SC-English bilinguals it was found that both age of acquisition, (AOA) and L2 proficiency affect the type of executive advantages and the corresponding attentional networks (Tao et al., 2011).

As with L2 acquisition, SC learners of English with different individual language histories and from different linguistic communities showed different L2 lexical categorization, indicating the importance of these two factors (Zinszer, Malt, Ameel, & Li, 2014). SC L2 learners of English were tested for cross-language transfer effects under syntactical violation, and the absence of such effects support the unified model of language acquisition (Tuninetti, Warren, & Tokowicz, 2014). Balanced and unbalanced SC-English bilinguals showed different neural correlates with the increasing load on phonological working memory (PWM), indicating the importance of PWM in language attainment (Chee, Soon, Lee, & Pallier, 2004).

SC was also used to study L2 reading of different types of scripts. Alphabetic language speakers learning SC as L2 showed different neural correlates of regularity effects in Chinese reading, compared with SC native speakers (Zhao et al., 2012).

1.2 Bilingualism of closely related dialects

Most previous bilingual studies focus on the bilingualism of different standard languages (e.g. English-Dutch, English-Spanish). Nevertheless, the bilingualism of closely related dialects (or languages), although very common, only received minimal attention. The limited studies are primarily present in machine translation (Xiaoheng Zhang, 1998), automatic (machine) speech recognition (Sproat et al., 2004), and the impact of local dialects on foreign language education (Feng & Adamson, 2014).

Although recently a few studies have investigated the speech perception (Sumner & Samuel, 2009; Xujin Zhang et al., 2012), lexical access (Xujin Zhang et al., 2012), and interlingual intelligibility (Gooskens, Kürschner, & van Bezooijen, 2011; Tang & van Heuven, 2009) of closely related languages and dialects, two aspects of interlingual alignments of the related phonological systems and their impact on the bilingual mental processing of speech recognition and production clearly invite more investigation. Different from two remote languages, two closely related languages or dialects not only show phonological similarity in their basic sound inventories, but also share a large number of etymologically related translation equivalents (including cognates and loan words). As a result, both phonological similarity and systematic correspondence are prevalent within the etymologically related translation equivalents.

In the present case, JM and SC both are northern Mandarin dialects. They have almost identical segmental inventories and similar tonal inventories (both with high-level, falling, and rising tones). Because of their historical relation, their etymologically related translation equivalents are usually segmentally identical and only vary in tonal similarity. To make it more interesting, the tones of the etymologically related words 'correspond systematically', according to the definition of systematic correspondence (Dyen, 1963; Meillet & Ford, 1967), so that the tonal categories of monosyllabic JM words are, to a large extent, predictable from the tonal categories of their SC translation equivalents. The introduction of Chapter 3 will provide more detailed descriptions of the phonological similarity and systematic correspondence in SC and JM with examples.

1.3 Bilingualism involving a common logographic writing system

Bilingual reading has been investigated in depth. Interlingual activation happens in automatic visual word recognition, either when the involved language uses the same type of orthography (Dyer, 1971; Preston & Lambert, 1969) or not (H.-C. Chen & Ho, 1986; Fang, Tzeng, & Alva, 1981; Kiyak, 1982). The within-language effect is usually greater than the between-language effect (H.-C. Chen & Ho, 1986; Fang et al., 1981; Preston & Lambert, 1969). However, a few studies have shown beginning L2 learners may experience between-language interference equally to (Kiyak, 1982), or even more than (H.-C. Chen & Ho, 1986) within-language interference when L2 is the response language in Stroop tests. The type of script affects visual word recognition. Users of alphabetic writing systems as learners of Chinese recruit different brain networks compared with native Chinese readers in reading phonological regular and irregular Chinese characters (Zhao et al., 2012). Between-language Stroop effects are also affected by the similarity of the scripts (Fang et al., 1981; Van Heuven, Conklin, Coderre, Guo, & Dijkstra, 2011).

However, bilingualism involving a common logographic writing system is little studied. Although this situation sounds very unlikely, it is quite common across Chinese dialects. For instance, in the present SC-JM case, the bilingual lexicon is teaming with etymologically related translation equivalents; and the bilinguals use the same Chinese characters for these pairs of SC-JM translation equivalents, such as the same Chinese character 蓝 for both the SC ‘blue’ /lan(High-rising) / and the JM ‘blue’ /lan(High-falling)/. Which information is activated in bilingual visual word recognition with these Chinese characters? Do tonal bilinguals read Chinese characters in the same way as tonal monolinguals?

1.4 Interlingual tonal mapping

As mentioned in the first section, Interlingual tonal perception has been investigated in naïve non-native listeners (So, 2010; Reid 2014). In addition to this, two-to-one interlingual mapping of phonemes is not a rare phenomenon in bilingualism and has been investigated intensively. One of the most famous cases is the mapping of English /r/ and /l/ with the Japanese apico-alveolar tap /ɾ/, with the Japanese /ɾ/ perceptually more similar to /l/ (Catherine T. Best & Strange, 1992; Miyawaki et al., 1975). Such a phenomenon can be approached from different directions, such as perceptual mapping (Aoyama, Flege, Guion, Akahane-Yamada, & Yamada, 2004; Iverson et al., 2003) and interlingual lexical competition (Cutler, Weber, & Otake, 2006).

However, how native tonal bilinguals process similar tonal categories from their two tonal systems remains unclear. Chapter 2 looks into the special situation of interlingual tonal mapping by SC-JM tonal bilinguals, namely the two-to-one interlingual tonal mapping of SC high-rising and low-rising tones with the JM rising tone. This two-to-one tonal mapping is investigated in the final position of disyllabic JM words and the corresponding SC pseudo-words. The native acoustic distributions of these three rising tones, as well as the interlingual identification of the JM rising tone by SC monolinguals, are compared and modeled with Generalized Additive Modeling (GAM). Then a semantic priming experiment investigates whether and how SC rising tones activate JM words in native bilinguals’ mental lexicon, and to what extent the interlingual category-goodness keeps its influence on speech comprehension.

1.5 Systematic correspondence between etymologically related translation equivalents

As mentioned in the second section, bilingualism involving related dialects has many etymologically related translation equivalents, which demonstrate systematical correspondence and phonological similarity. These two phonological alignments between two vocabularies have received intensive attention from historical linguistics since the early studies of historical comparison (Dyen, 1963; Meillet & Ford, 1967). However, they have received relatively less attention from psycholinguistics and speech engineering. These two aspects are mainly studied in Chapter 3 and 4.

Chapter 3 carries out an explorative study, trying to statistically model the pitch between JM words from the tonal relation of their SC translation equivalents. This study is primarily based on the rule of systematic correspondence, which predicts that, if two words are from the same phonological category in one language, their etymologically related translation equivalents in the corresponding language are also more likely to come from the same phonological category, although the involved phonological categories from the two languages may sound very different.

Besides statistically verifying the effects of systematic correspondence, the present study also investigates how different sociolinguistic and cognitive backgrounds affect the strength of systematic correspondence in bilingual individuals. Individual backgrounds are incorporated into the modeling of systematic correspondence. Also, age-dependent and age-independent effects are statistically separated to clarify the general sources of individual variability in the bilingual society. The results may be interesting for the linguistic studies of language contact and language evolution, as well as for the practice of speech engineering.

1.6 Phonological similarity and lexical variants of etymologically related translation equivalents

Interlingual similarity of phonological categories is common in bilingualism and we have given a brief introduction to the SC-JM interlingual two-to-one tonal mapping in a previous section (Interlingual Tonal Mapping) and a more detailed investigation will be given in Chapter 2. Nevertheless, only closely related languages (or dialects) or languages in close contact have a lot of phonologically similar translation equivalents. Phonological identity is an extreme form of phonological similarity. In the current section, a general introduction is given for Chapters 4 and 6, which investigates the effects of phonological similarity in the bilingual mental lexicon and lexical access under the assumption of an integrated bilingual lexicon (Kroll, Bobb, & Wodniecka, 2006).

Etymologically related translation equivalents include both cognates and loan words, which are difficult to distinguish in closely related dialects. Using ‘cognates’ to refer to all etymologically related translation equivalents, psycholinguists have found ‘cognate facilitation effect’ in many different tasks and conditions. For instance, ‘cognates’ are processed faster in both production (Costa, Caramazza, & Sebastian-Galles, 2000; Hoshino & Kroll, 2008) and visual word recognition (Brenders, van Hell, & Dijkstra, 2011; Bultena, Dijkstra, & van Hell, 2012; Dijkstra, Grainger, & Van Heuven, 1999). ‘Cognate facilitation’ comes both from the sharing of orthography and phonology. There have been many studies trying to tear them apart, where the orthographic effect is more robust than the phonological effect

(Dijkstra et al., 1999; Dijkstra, Miwa, Brummelhuis, Sappelli, & Baayen, 2010; Duyck, Assche, Drieghe, & Hartsuiker, 2007; Lemhöfer & Dijkstra, 2004).

SC-JM provides an ideal case to test the tonal 'cognate effect' aurally, in that the translation equivalents are mostly etymologically related. Also these etymologically related translation equivalents are mostly identical in segmental structure and orthography, and vary only in tonal similarity. Thus, the phonological similarity between a pair of SC-JM etymologically related translation equivalents only depends on the tonal similarity.

Chapter 4 investigates the role of tone in the auditory lexical access of etymologically related translation equivalents. SC-JM tonal bilinguals and SC monolinguals make auditory lexical decisions about tone-identical and tone-non-identical translation equivalents, with the tonal similarity of each pair assessed afterwards. The naming latencies are measured and compared across different types of translation equivalents, as well as between tonal bilinguals and tonal monolinguals, in order to investigate the lexical representation of these SC-JM translation equivalents.

Possibly due to lack of standardization and heavy language contact, many JM words in speech production show tonal pattern variability, a variability between tonal lexical variants. Chapter 5 investigates the roles of three different types of tonal variability in JM auditory lexical access, with a focus on the tonal pattern variability. This is a type of variability with lexical variants of the same word carrying distinctive tonal patterns, which are lexically non-contrastive but potentially contrastive in other words. This is a case similar to the vowel variability of /a:/ and /ei/ in the British and American pronunciation of 'tomato'. What differs is that the tonal pattern variability exists within the same language and used by the same speaker. The form priming results show that tonal pattern variants induced a similar but smaller facilitation effect compared with the acoustic identity and the within-category variation, which is different from the inhibition effect in the lexically contrastive condition. Thus, tonal patterns may have representative status but can converge in a lexically specific way in lexical access.

In Chapter 6, the storage of tonal pattern variants is investigated with the tonal bilingualism under consideration. Taking the phenomena discussed in Chapter 4 and Chapter 5 together, some JM words in JM-only mode are produced with different lexical variants with distinctive tonal patterns and one of the variants is identical to the SC translation equivalent (variant_id). Moreover, in a corpus including different speakers, the word-wise probability of variant_id varies across words, ranging from 0 to 1. Do the bilinguals who only produce the variant_id also store the non-identical variant in their mental lexicon? In previous studies, variant frequency effect is used to support the separate lexical representations of the flapping and non-flapping variants of American English consonant /t/ (Connine, Ranbom, & Patterson, 2008). In Chapter 6, the variant frequency effects on the naming latencies of JM words are tested to investigate the lexical representation of the interlingual identical and non-identical variants.

1.7 Automatic bilingual phonological activation from the common written forms

As mentioned in the third section, in earlier studies, bilingualism involving the same type of orthography has been compared with bilingualism involving different types of orthographies (Fang et al., 1981; Van Heuven et al., 2011). However, the usage of exactly the same written forms for translation equivalents in bilingualism is little studied.

Regarding the visual word recognition of Chinese, a logographic writing system, phonological effects have been investigated in depth in previous studies. It was found very early that phonological information is retrieved in Chinese character recognition (Tzeng, Hung, & Wang, 1977). A meta-study shows that the brain regions involved in phonological processing differ between Chinese characters and written alphabetic words (Tan, Laird, Li, & Fox, 2005). Behavioral studies found that, different from alphabetic writing systems, Chinese characters can be identified without mediation from phonemic processes (Perfetti & Zhang, 1991). Another study found that evidence for phonological mediation is only restricted to words with relatively thin homophone density (Tan & Perfetti, 1997). Although the phonological activation can happen automatically and early in visual word identification (Perfetti & Zhang, 1991, 1995), it mostly occurs postlexically (Perfetti & Zhang, 1991; Zhou & Marslen-Wilson, 2000). Various priming experiments found that the existence of phonetic radicals affects the speed and the role of phonological activation in Chinese visual word identification (N. Wu, Zhou, & Shu, 1999; Zhou & Marslen-Wilson, 1999b) and the phonological activation is largely mediated by the phonetic radicals (Zhou & Marslen-Wilson, 1999a). Nevertheless, these studies did not take into consideration that a large proportion of Chinese readers use exactly the same characters for translation equivalents from different Chinese dialects. With these bilinguals, which phonological representations are activated by the common Chinese character, and whether the different tonal representations from both dialects are automatically activated via the same Chinese character needs more investigation.

In Chapter 7, the automatic phonological activation of Chinese characters is tested in Stroop experiments. Similar to earlier Chinese Stroop experiments (C. Li, Lin, Wang, & Jiang, 2013; Spinks, Liu, Perfetti, & Tan, 2000), participants name the ink color of different words written in different colors, and the naming latencies and accuracies are measured. However, different from previous studies, the SC-JM tonal bilinguals and SC tonal monolinguals are tested separately and in different dialect modes. The within-dialect and between-dialect phonological sharing between the character and color names is manipulated, in order to assess the tonal and segmental effects. The Stroop facilitation and interference are measured both on the tonal bilinguals and tonal monolinguals, in order to investigate the bilingual effect. The results are compared with previous findings and discussed in light of tone-specific bilingual attention control.

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[i] Chapter 5 has been published: Wu, J., Chen, Y., Van Heuven, V. J., & Schiller, N. O. (2014). *Tonal variability in lexical access*. Language, Cognition and Neuroscience. doi: 10.1080/23273798.2014.915977.

Chapter 6 has been included in the proceeding of a conference: Wu, J., & Chen, Y. (2014). *Tonal variants in the bilingual mental lexicon.* Paper presented at the the Fourth International Symposium on Tonal Aspects of Languages (TAL 2014), Nijmegen.

Part of Chapter 3 has been presented as a poster in a conference: Wu, J., Chen, Y., & Schiller, N. O. (2015). *Aging and Age-Independent Effects of Cognitive and Sociolinguistic Backgrounds: on the Strength of Tonal Systematic Correspondence by Tonal Bilinguals*. Paper presented at the Bilingualism and Cognitive Aging, Groningen.

Chapters 2, 3, and 4 have been submitted to journals. Chapter 7 is in preparation for submission.

[ii] However, SC is not equivalent to Beijing Mandarin, because some of the morphological lexical variants (i.e. variants with 'Erhua' erization) and specific words from Beijing Mandarin were not introduced into SC in the standardization. Nowadays many young Beijing citizens also speak SC instead of real Beijing Mandarin or use accents closer to SC in formal situations.

[iii] Low-falling+Low sandhi pattern also exists in some speakers

[iv] The oldest speakers recorded by Qian (1997) still distinguished the vowel [ɛ] used in [ʨiɛ] 'connect' and the vowel [e] used in the other words of this minimal set. However, the younger speakers seem to use [ɛ] for all these words.

v In this book, the terms 'tonal bilinguals' and 'tonal monolinguals' are used to refer to SC-JM speakers from Jinan and SC speakers from Beijing. This terminology focuses on the speakers' experience with tonal dialects. It does not rule out the possibility that both groups may speak other non-tonal languages with some proficiency, i.e. English, German, or French.

[vi] Tai and other tonal languages within China are in long-term close contact with local Chinese dialects (usually Southwestern Mandarin) and in the last 30 years also with Standard Chinese. There has been a long history of debate over the historical relationship between these languages and Chinese (Benedict, 1942; F.-k. Li, 1973; Matisoff, 2003). It is nevertheless clear that the dialects of these tonal languages within the borders of China share a considerable number of (etymologically) related words with Chinese (although it is still under debate whether these related words come from a common origin or early borrowing). Tonal bilingualism is a common phenomenon among the speakers of these languages in China.