A psycholinguistic investigation of speech production in Mandarin Chinese

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Chapter 6

General Discussion

This dissertation investigates the speech production of Mandarin Chinese from a psycholinguistic approach. Why is it interesting to investigate Mandarin Chinese speech production? From a theoretical point of view, current psycholinguistic models of speech production have been mainly based on evidence from West Germanic languages, where orthographic and phonological forms follow a certain mapping captured in grapheme-to-phoneme conversion (GPC) rules. By contrast, in languages with a logographic script such as Mandarin Chinese, GPC is more opaque, which may result in a (different) role for orthography in speech production. Previous research on the speech production of languages with a logographic script has also provided empirical evidence suggesting the need of modifications to the current speech production models (e.g. Qu, Damian, & Li, 2016; Verdonschot, 2011; Zhang, Chen, & Weekes, 2009; Zhang & Weekes, 2009).

This dissertation provided direct evidence, first with reaction time measurements, for the involvement of orthography in speech production in Mandarin Chinese (Chapter 2) and that the orthographic effect on speech production was rather independent. That is, the orthographic representation of a lexical item exerted its effect without interacting with its semantic or phonological representations (Chapter 3). The following chapter then provided electrophysiological evidence supporting relatively early semantic processing and relatively late phonological form encoding in Mandarin Chinese (Chapter 4) as well as electrophysiological evidence supporting the automatic activation of lexico-syntactic features in speech production of Mandarin Chinese (Chapter 5).

Chapter 1 introduced the current psycholinguistic models of speech production. Most models agree that to overtly produce a word, speakers go through several stages: conceptual preparation, lemma retrieval, word-form encoding and articulation (e.g., Caramazza, 1997; Dell & Seaghdha, 1991, 1992; the WEAVER++ model, Levelt et al., 1999a, b; Roelofs, 1992; Roelofs & Meyer, 1998). At the word-form encoding stage, word form usually refers to the phonological form of the word. Note that the Independent Network theory does specifically recognize an orthographic representation and a phonological representation of the lexical item, but only hypothesizes a role of orthography in written word production (e.g. Caramazza, 1997; Rapp & Caramazza, 2002).

Subsequently, this dissertation pointed out that in languages with a logographic script like Mandarin Chinese, the orthographic representation of a lexical item - Chinese characters had a critical role in distinguishing homophones and might therefore be involved in speech production. Furthermore, the speech production mechanisms of Mandarin Chinese might differ from the predictions of current speech production models.

As the first experimental chapter, **Chapter 2** directly tapped into the question whether orthography was involved in speech production of Mandarin Chinese. No consensus has been reached in terms of the involvement of orthography in speech production. Empirical evidence was reported to suggest the mandatory activation of orthography in speech production in English (Damian & Bowers, 2003) in the form-preparation paradigm (Meyer, 1990, 1991). More specifically, inconsistent spelling (e.g. 'giant', 'jewel', 'joker') in a phonologically homogeneous context disrupted the form-preparation effect. The authors (Damian & Bowers, 2003) also conducted a post hoc analysis on previous studies in Dutch (Meyer, 1990, 1991) but did not find a similar disruptive effect caused by the orthographic inconsistency. Similarly, in a later study using visually masked primes to test reading aloud in Dutch, the

orthographically related primes (e.g. 'cement', *concrete*) did not speed up the reading responses of the targets (e.g. 'congres', *congress*) (Schiller, 2007). Moreover, the mandatory involvement of orthography was not observed in French (Alario, Perre, Castel, & Ziegler, 2007) or Chinese (Chen, Chen, & Dell, 2002).

One possible explanation for the discrepancy is that the involvement of orthography may be task-dependent. For instance, orthographic inconsistency showed an inhibitory effect in a word-reading task in the form-preparation paradigm but not in picture naming, word generation or associative naming. This task-dependent characteristic is consistent in Dutch (Roelofs, 2006) and Chinese (Bi, Wei, Janssen, & Han, 2009). These findings seem to suggest that only in tasks where the orthographic information is highly relevant, there may be the involvement of orthography in speech production. Another possibility is that the discrepancy may be attributed to the cross-linguistic differences. As discussed in Damian and Bowers (2003), compared to Dutch, in English the mapping between orthography and phonology is more opaque, which may result in the involvement of orthography in speech production in English.

Aiming to resolve the discrepancies, in Chapter 2, we re-investigated the role of orthography in Mandarin Chinese using an adapted blocked cyclic naming paradigm. In this paradigm, participants were asked to overtly name pictures that were presented repeatedly in semantically homogeneous, phonologically homogeneous, or heterogeneous blocks. On each trial, a written Chinese character that was either orthographically related or unrelated to the target was briefly presented (for 75 ms) before the target picture. We measured participants' speech onset latencies. Consistent with previous research, an inhibitory semantic blocking effect and a facilitative phonological blocking effect were found. More importantly, we observed that the orthographically related characters facilitated picture naming in both the semantic and

phonological blocks. In addition, the orthographic priming effect was independent of both the semantic and the phonological effects. These findings suggested that orthography contributes to speaking in a picture naming task, lending further support to the presence of orthographic priming in spoken word production, even in a language with a logographic script like Chinese.

The contribution of orthography to speech production in Mandarin Chinese lent support to the suggestion that in a language with relatively opaque mapping between orthography and phonology, orthography was involved in speech production (Damian & Bowers, 2003). As for the claim that orthography was only involved when highly relevant for production (e.g. in reading tasks; Roelofs, 2006), we offered extra empirical evidence for future discussions. In the adapted blocked cyclic naming paradigm, the Chinese characters were very briefly presented and the participants barely had time to consciously process the characters. Still, an orthographic priming effect was demonstrated. This finding contrasted with the null effect of orthography in picture naming in Chinese (Bi et al., 2009), however, the contrastive results could be attributed to various reasons (e.g. stimuli sets, participant groups, experimental task).

In Chapter 2, we found an orthographic facilitation effect, indicating that the activation of an orthographic representation could facilitate lexical access in spoken word production. The effect was present from the first cycle in the blocked cyclic naming paradigm with orthographic priming, and thus could not have originated from a learning phase (see Alario et al., 2007).

Chapter 3 investigated when and how orthography was involved during speech production. In previous research, the orthographic effect was observed at a similar stage to the semantic effect without the co-occurrence of any phonological effect. It was then suggested that orthography affected speech production via a lexico-semantic pathway (Zhang et al., 2009; Zhang & Weekes,

2009; Figure 6.1). The critical evidence that supported this claim was that the orthographic effect was observed at negative SOAs but this observation was not replicated in a later study (Zhao, La Heij, & Schiller, 2012). This chapter attempted to replicate it but did not observe any orthographic effect at negative SOAs in Experiments 1 or 2, suggesting that it was unlikely that orthography affected speech production of Mandarin Chinese via a lexico-semantic pathway.

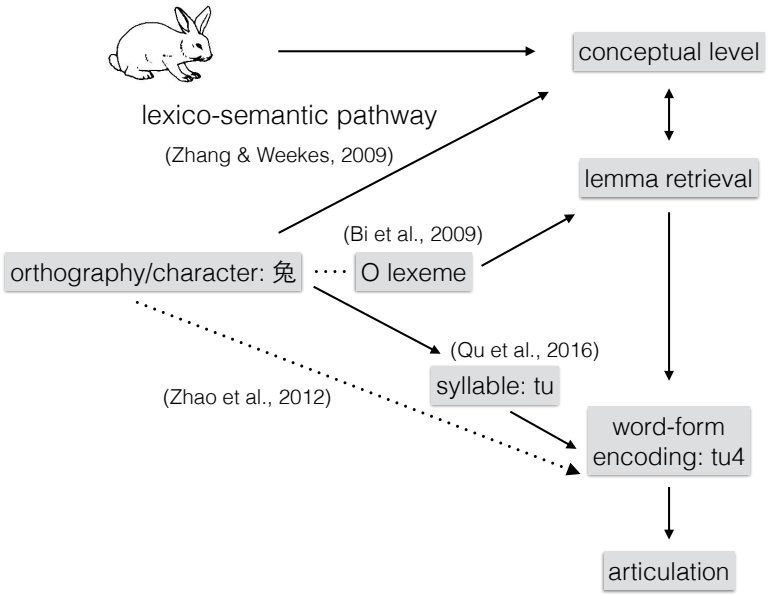

Figure 6.1 An overview of predications on the orthographic effect on speech production of Mandarin Chinese.

In Experiment 2 of Chapter 3, we took a step further and used simplex characters only so as to clearly dissociate orthography from the semantic representation and phonological representation. Consistent with the finding in Zhao et al. (2012), the orthographic effect was observed with the co-

occurrence of the phonological effect, subsequent to the semantic effect. In previous research, Bi and colleagues (Bi, Xu, & Caramazza, 2009) elaborately discussed the possible routes of the orthographic effect on speech production. The authors suggested that pure orthographic relatedness (i.e. semantically and phonologically unrelated) facilitated speech production at the lexical level (Bi et al., 2009; Figure 6.1). More specifically, the orthographically related distractors activated the orthographic neighbors, including the orthographic representation of the target and activation spread to the target lemma (Bi et al., 2009). If this was the case, we should have observed that the orthographic effect arose at a similar stage to the semantic effect. Such a pattern, however, was not observed in Experiments 1 or 2.

Alternatively, Zhao and colleagues (Zhao et al., 2012) claimed that the orthographic relatedness might affect speech production at a similar stage to the phonological relatedness, i.e. the word-form encoding stage. Nevertheless, in speech production, orthographic word form encoding is not necessary. Therefore, the only way for orthography to affect the word-form encoding stage is to facilitate the phonological form retrieval and encoding. We made use of the simplex characters, i.e. characters without phonetic radical, so that the GPC route was ruled out as a possible pathway. This suggests that orthographic relatedness may affect another sub-lexical level, i.e. the character-to-syllable correspondence (Qu et al., 2016; Figure 6.1). More specifically, for a target (e.g. 兔, tu4, 'rabbit'), the orthographically related distractor (e.g. 免, mian3, 'exemption') activated its orthographic neighbors (e.g. 兔, tu4, 'rabbit'), which, consequently, activated character activated its syllable (tu4) and facilitated the speech production of the target.

Besides drawing evidence from behavioral data, in recent decades, researchers have increasingly used electrophysiological measurements to investigate the underlying mechanisms of speech production (Christoffels, Firk,

& Schiller, 2007; Koester & Schiller, 2008; see Ganushchak, Christoffels, & Schiller, 2011 for a review). With the high temporal resolution of electrophysiological measurements, Chapters 4 and 5 tapped into the time course and the neural correlates of speech production of Mandarin Chinese.

Chapter 4 investigated the neural correlates of semantic and phonological processing in speech production of Mandarin Chinese. Firstly, consistent with the findings in Chapter 2 and previous research, longer naming latencies were shown in semantically homogeneous blocks and shorter naming latencies in phonologically homogeneous blocks, relative to the heterogeneous blocks. Then, in the electrophysiological data, it was shown that the semantic factor significantly modulated electrophysiological waveforms from 200 ms and the phonological factor from 350 ms after picture presentation. The results were consistent with the estimation of meta-analyses on the neural correlates of speech production (Indefrey & Levelt, 2004; Indefrey, 2011; Strijkers, Costa, & Thierry, 2010) and studies using the go/no-go task (e.g. Van Turennout, Hagoort, & Brown, 1997) and the picture-word interference task (Zhu, Damian, & Zhang, 2015). This suggested that the speech production of Mandarin Chinese also involved an earlier semantic processing and a later phonological processing and the temporal loci of these two stages were in line with those of the estimation of speech production in general.

The previous chapters tested the semantic, orthographic and phonological processing during speech production of Mandarin Chinese. **Chapter 5** tapped into a more specific detail in the process of speech production; that is, whether a word's syntactic features (e.g. number, grammatical gender, etc.) were automatically activated and selected in bare noun production. Previous research has shown that the lexico-syntactic features are activated and selected in noun phrase production when these features are necessary for production (e.g., de arm, 'the arm', *common gender*, 'het been', 'the leg', *neuter gender*; see Caramazza,

Miozzo, Costa, Schiller & Alario, 2001 for a review). However, it has been debated if the lexico-syntactic features are activated and selected in bare noun production when these features are irrelevant for production (e.g., 'arm', 'been'; see, La Heij et al., 1998; Starreveld & La Heij, 2004 for a null effect of grammatical gender in bare noun production in Dutch; Cubelli, Lotto, Paolieri, Girelli, & Job, 2005 for an effect of grammatical gender in bare noun production in Italian; Tsegaye, Mous, & Schiller, 2014 for an effect of plural gender and masculine/feminine gender noun productions in Konso). In Mandarin Chinese, although gender or case is not overtly marked, it is compulsory to use a classifier between a demonstrative and/or numeral and its associated noun. In psycholinguistic research, classifier information is considered comparable to grammatical gender information (Tzeng, Chen, & Hung, 1991).

Using the picture-word interference paradigm, we manipulated the congruency of Mandarin Chinese classifiers between the target picture (e.g. 'coat', *classifier-jian4*) and the superimposed distractor word (e.g. 'luggage', *classifier-jian4* or 'rabbit', *classifier-zhi1*). We measured the participants' naming latencies and their electroencephalogram (EEG). As a result, classifier incongruency elicited a stronger N400 effect in the ERP analyses, suggesting the automatic *activation* of lexico-syntactic features in bare noun production. However, classifier congruency did not affect naming latencies, suggesting that the lexico-syntactic feature was not *selected* in bare noun naming when it was irrelevant for production. The null effect of classifier congruency in naming latencies was in line with the results in Wang, Guo, Bi and Shu (2006) for Chinese and Dutch (La Heij et al., 1998; Starreveld & La Heij, 2004) but contradicted the results in Zhang and Liu (2009) in Chinese and Italian (Cubelli et al., 2005). It is possible that for speech production in languages with relatively simple morphological structures, the selection at the lexico-syntactic layer is not necessary (see Cubelli et al., 2006 for a detailed account of a two-

layer architecture for language production). Moreover, the automatic activation of classifier information may be attributed to the fact that Mandarin speakers acquire and memorize the classifier-noun combination at very young ages and the classifier feature receives activations spread from the activated lemma.

In short, this study of classifier effects provided insights to the comparison with regard to lexico-syntactic feature encoding between spoken word production in West-Germanic languages (where gender is a prominent feature) and that in East Asian languages (where classification is a prominent feature).

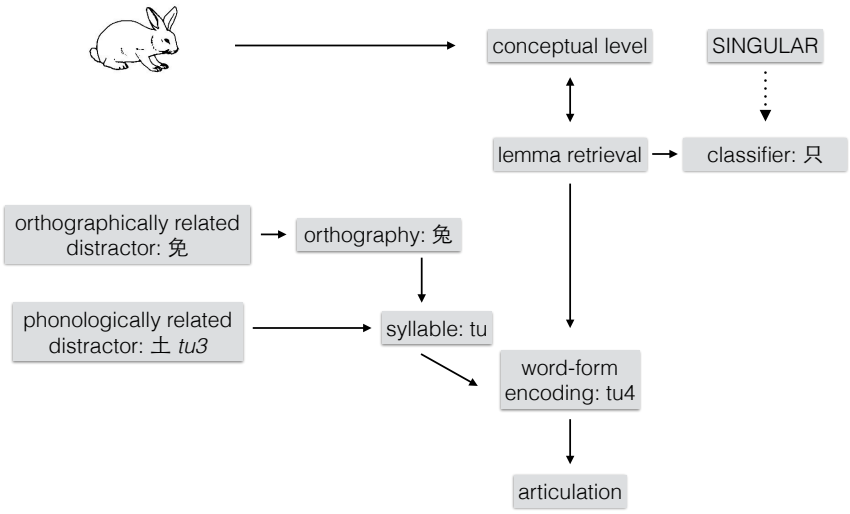

Figure 6.2 The speech production of Mandarin Chinese in the context of orthographically, phonologically or classifier related distractors.

Conclusion and implications for future research

In summary, this dissertation investigated the speech production processes and mechanisms in Mandarin Chinese from a psycholinguistic

perspective. The characteristic opaque grapheme-to-phoneme correspondence in Chinese provides an interesting test case for speech production, especially with regard to the separate roles of orthography and phonology. Results of the experiments reported in this dissertation show that orthography contributes to speech production, probably by activating its orthographic neighbor and then the corresponding target syllable. In addition, pure orthographic relatedness can affect speech production independently without interacting with semantic or phonological representations. Moreover, this dissertation used electrophysiological measurement to investigate the fine-grained time course of speech production in Mandarin Chinese. It was shown that the semantic factors modulated the electrophysiological signals from 200 ms and the phonological factor from 350 ms after stimulus presentation. It was also shown that the lexico-syntactic feature (Chinese classifier) was automatically activated in speech production even when it was not necessary for production.

This dissertation tapped into the semantic, orthographic and phonological effects in speech production in Mandarin Chinese in the framework of current psycholinguistic models of speech production. The findings in this dissertation not only contribute to the understanding of the underlying neuropsychological mechanisms of speech production in Mandarin Chinese, but also provide insights into the understanding of the accountability of current models of speech production that are mostly based on evidence from West Germanic languages.

For future studies, it would be interesting to look into the proximate unit of phonological encoding in speech production of Mandarin Chinese. It has been debated that the proximate unit is the syllable (Chen et al., 2002; O'Seaghdha, Chen, & Chen, 2010), the phonemic segment (Qu, Damian, & Kazanina, 2012), or a sub-syllabic unit (Verdonschot et al., 2015). While investigating the phonological encoding in this dissertation, it was shown that

the sub-syllabic overlap modulated brain signals from 350 ms after stimulus presentation (Chapter 4). The existence of this effect may be attributed to the phenomenon that young generations of speakers of Mandarin Chinese, our participant population, tend to type *pinyin* (the phonetic notation of Chinese characters) instead of writing characters. With regard to the finding in Chapter 5, it would be interesting to extend the electrophysiological measurement to test the lexico-syntactic encoding at the phrasal level and determine the temporal locus of lexico-syntactic encoding in speech production.

Moreover, Chapters 4 and 5 lend further evidence to the feasibility of investigating overt speech production with the electrophysiological measurement (Christoffels et al., 2007; Koester & Schiller, 2008; see Ganushchak et al., 2011 for a review). On the one hand, the electrophysiological measurement can provide fine-grained data to test the detailed time course of speech production. On the other hand, the correlation between he electrophysiological and behavioral data can provide a more solid reference for data interpretation.

To conclude, this dissertation provides empirical evidence for the understanding of the speech production processes and mechanisms in Mandarin Chinese, a language with a logographic script. It also contributes to the understanding of psycholinguistic models of speech production in general.