Towards a Model of Second Language Word Production and Recognition in Mandarin
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Abstract
The production and recognition of Mandarin words by Cantonese speakers are influenced by the pronunciation correspondences between Cantonese and Mandarin in all sublexical levels (i.e., onset, rime and tone). A three-route second language word production and recognition model is proposed using these pronunciation correspondences. A concept route links the concept and the L2 Mandarin phonological representation directly, while a lexical route links the concept and the L2 Mandarin phonological representation through the L1 Cantonese phonological representation. A sublexical route activates the concept and/or the L2 Mandarin phonological representation through the mediation of L1 Cantonese phonological and sublexical representation using Cantonese-Mandarin pronunciation correspondences. Beginning learners of Cantonese mainly use the sublexical route in L2 Mandarin word production and recognition. Advanced learners gradually shift from the sublexical to lexical/concept route in producing Mandarin words while both lexical/conceptual and sublexical routes are still in active use to generate possible word candidates in L2 Mandarin word recognition. Evidence for the proposed model is drawn from a Mandarin word production task, a Mandarin disyllabic word transcription task, a Mandarin pinyin transcription task, and a character-sound matching task. Further testing of the model in the neurolinguistics and computational domain are also proposed.

Introduction
It is well documented (e.g., Lado, 1967) that second language (L2) speech produced by non-native speakers is influenced by the phonetic, phonological and prosodic system of their first language (L1). For example, Cantonese speakers sometimes mispronounce the English word ‘right’ as ‘white’ due the lack of the phoneme /r/ in their L1. Cantonese-accented Mandarin reveals another kind of negative transfer where accent is realized at the lexical level. There are many homophones in Cantonese and Mandarin, but homophones in Cantonese may not be homophones in Mandarin (e.g., the pair 尾 ‘tail’ and 美 ‘beauty’, are both pronounced mei5 in Cantonese, but wei3 and mei3 in Mandarin respectively; the pair 声 ‘sound’ and 星 ‘star’ are both pronounced sing1 in Cantonese, but sheng1 and xing1 in Mandarin respectively). It has been mentioned in the Mandarin learning literature that Cantonese speakers may mistakenly think that words that are homophones in Cantonese are also homophones in Mandarin (e.g., Tsang-Cheung, L. Y., 1988, Zeng, 2009). Adapting the Revised Hierarchical Model of bilingual processing (Kroll & Stewart, 1994), Chu and Taft (2010) proposed an L2 Mandarin word production model for Cantonese learners of Mandarin to explain the negative homophonic transfer from L1 Cantonese to L2 Mandarin. The model
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is illustrated in Figure 1 using the Cantonese homophones 尾 ‘tail’ and 美 ‘beauty’ as examples.

Figure 1. L2 Mandarin word production model

In the model, there is one common conceptual system for both Cantonese and Mandarin while there are separate lexical systems for Cantonese and Mandarin storing word specific information (i.e., phonological and morphosyntactic information). The L2 Mandarin phonological representations sheng1 and xing1 have strong lexical links to the same L1 Cantonese phonological representation sing1 and there are strong conceptual links between the L1 Cantonese phonological representation sing1 and the concepts ‘sound’ and ‘star’ respectively. The direct conceptual link between the concepts and the L2 Mandarin phonological representation is not developed yet for beginning Cantonese learners of Mandarin (hence the dashed lines), so their production of L2 words from concepts is mediated through the L1 Cantonese phonological representation. As the L1 Cantonese phonological representation sing1 is linked to both L2 Mandarin phonological representations sheng1 and xing1, Cantonese speakers may sometimes mispronounce the word ‘sound’ as /xing1/ and the word ‘star’ as /sheng1/. With increasing L2 Mandarin proficiency, Cantonese speakers gradually develop a direct link between the concepts and the L2 Mandarin phonological representations. They may use this direct conceptual link to produce L2 words more often than the links mediated through L1 as the latter may sometimes lead to the activation of an incorrect L2 Mandarin phonological representation.

In order to examine this model, Cantonese learners of Mandarin were asked to pronounce Cantonese homophonic words in a Mandarin word production task (Chu & Taft, 2010). The production data showed that homophonic transfer is not symmetrical. For example, the mispronunciation of the word 聲 ‘sound’ as /xing1/ was observed more often than the mispronunciation of the word 星 ‘star’ as /sheng1/. Also, there was mispronunciation of the word 尾 ‘tail’ as /mei3/ but not in the reverse direction (i.e., mispronunciation of the word 美 ‘beauty’ as /wei3/). In addition, there were some other mispronunciations (e.g., /mi3/ for the word 尾 ‘tail’) that cannot be explained by the
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The proposed model as the mispronunciation /mi3/ is not one of the activated Mandarin phonological representations (i.e., mei3 and wei3).

In order to account for the above findings, Chu and Taft (2010) proposed that the Mandarin word productions of Cantonese speakers are also influenced by pronunciation correspondences between Cantonese and Mandarin below the word level (i.e., the “sublexical” structures of onset and rime). Previous studies have shown that there are pronunciation relationships between Cantonese and Mandarin (Tsang-Cheung, L. Y., 1988, Zhang & Gao, 2000). To illustrate, the Cantonese onset /m/ and rime /ei/ and their corresponding Mandarin pronunciations are shown in Tables 1 and 2. For words that are pronounced with the Cantonese onset /m/, 82% are pronounced with the onset /m/ in Mandarin. For words that are pronounced with the Cantonese rime /ei/, 77% are pronounced with the rime /i/ in Mandarin. When Cantonese speakers are exposed to the Mandarin pronunciations, they may gradually extract the statistical regularities between Cantonese and Mandarin pronunciations.

Table 1. Cantonese-Mandarin pronunciation relationships for Cantonese onset /m/

<table>
<thead>
<tr>
<th>Mandarin onset</th>
<th>Number of words</th>
<th>Percentage</th>
<th>Example</th>
<th>Cantonese / Mandarin pronunciations</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>160</td>
<td>82%</td>
<td>媽 ‘mother’</td>
<td>ma1 / ma1</td>
</tr>
<tr>
<td>w</td>
<td>33</td>
<td>17%</td>
<td>萬 ‘ten thousand’</td>
<td>maan6 / wan4</td>
</tr>
<tr>
<td>b</td>
<td>2</td>
<td>1%</td>
<td>剝 ‘to shell’</td>
<td>mok1 / b01, bao1</td>
</tr>
</tbody>
</table>

Table 2. Cantonese-Mandarin pronunciation relationships for Cantonese rime /ei/

<table>
<thead>
<tr>
<th>Mandarin rime</th>
<th>Number of words</th>
<th>Percentage</th>
<th>Example</th>
<th>Cantonese / Mandarin pronunciations</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>99</td>
<td>77%</td>
<td>皮 ‘skin’</td>
<td>pi4 / pi2</td>
</tr>
<tr>
<td>ei</td>
<td>26</td>
<td>20%</td>
<td>悲 ‘sad’</td>
<td>bei1 / bei1</td>
</tr>
<tr>
<td>others</td>
<td>3</td>
<td>3%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2 illustrates the revised three-route L2 Mandarin word production model incorporating the sublexical route in additional to the original concept and lexical route (Chu & Taft, 2010). The L1 Cantonese phonological representation now activates its sublexical representations (i.e., onsets and rimes) along with activating its L2 Mandarin phonological representations directly. The activated L1 Cantonese sublexical representations then activate their corresponding L2 Mandarin sublexical representations whose activation levels are assumed to be proportional to the percentage of pronunciation correspondence between Cantonese and Mandarin as shown in the figure (The strongest activation from L1 Cantonese to L2 Mandarin sublexical representation in each sublexical unit is shown in bold). Different L2 Mandarin sublexical representations then recombine to activate the L2 Mandarin phonological representations. The activation of the L2 Mandarin phonological representations through the sublexical route are assumed to be the multiplication of the activation of the
corresponding L2 Mandarin onset and rime (as shown in the figure).

Figure 2. L2 Mandarin word production model incorporating the sublexical route

As beginning Cantonese learners of Mandarin may rely more on the sublexical route in the activation the L2 Mandarin phonological representations, the mispronunciation of the word ‘tail’ as /mi3/ in Mandarin can be explained as it is one of the activated L2 Mandarin phonological representations and this L2 Mandarin phonological representation has the highest activation through the sublexical route (shown in bold in Figure 2). In addition, the model can explain the pattern of asymmetrical negative homophonic transfer. From the figure, it is shown that no matter whether the concept is ‘tail’ or ‘beauty’, the L2 Mandarin phonological representation mei3 has a higher activation level than that of wei3 using the sublexical route (14% vs. 3%). This can explain why Cantonese learners of Mandarin sometimes mispronounced ‘tail’ as /wei3/, but did not mispronounce ‘beauty’ as /mei3/.

**Incorporating the tone component in the L2 Mandarin word production model**

The L2 Mandarin word production model in Figure 2 includes onset and rime only. However, Cantonese and Mandarin are tone languages where a change in the pitch and/or contour of a syllable changes the meaning of a word (e.g., Gandour, 1981). Apart from the pronunciation relationships between Cantonese and Mandarin onsets and rimes, there are also systematic pronunciation relationships between Cantonese and Mandarin tones (Zhang & Zhang, 2000) and the major tone correspondences between Cantonese and Mandarin words are shown in Table 3. For example, among all the words that are pronounced with tone 2 in
Cantonese, 89% are pronounced with tone 3 in Mandarin (e.g., 找 ‘find’) and these words are referred to as ‘regular-tone’ words. Those that do not follow the dominant correspondence (e.g., 帽 ‘hat’, pronounced with Cantonese tone 2, but Mandarin tone 4) are referred to as ‘irregular-tone’ words.

Table 3. Major tone correspondences between Cantonese and Mandarin words

<table>
<thead>
<tr>
<th>Cantonese tone</th>
<th>Mandarin tone</th>
<th>Correspondence percentage</th>
<th>Example Cantonese pronunciation</th>
<th>Example Mandarin pronunciation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (high level)</td>
<td>1 (level)</td>
<td>93%</td>
<td>郊 ‘suburb’</td>
<td>jiao1</td>
</tr>
<tr>
<td>2 (high rising)</td>
<td>3 (dipping)</td>
<td>89%</td>
<td>找 ‘find’</td>
<td>zaau2</td>
</tr>
<tr>
<td>3 (mid level)</td>
<td>4 (falling)</td>
<td>92%</td>
<td>怪 ‘strange’</td>
<td>gwai2</td>
</tr>
<tr>
<td>4 (low falling)</td>
<td>2 (rising)</td>
<td>93%</td>
<td>牛 ‘cow’</td>
<td>ngaau4</td>
</tr>
<tr>
<td>5 (low rising)</td>
<td>3 (dipping)</td>
<td>75%</td>
<td>伟 ‘great’</td>
<td>wei2</td>
</tr>
<tr>
<td>6 (mid-low level)</td>
<td>4 (falling)</td>
<td>94%</td>
<td>又 ‘again’</td>
<td>jau6</td>
</tr>
</tbody>
</table>

The L2 Mandarin word production model in Figure 2 can be extended to incorporate the tone component and it is illustrated in Figure 3 using a regular- and an irregular-tone word as an example. The percentages shown between the L1 Cantonese and L2 Mandarin sublexical (i.e. tone) representation correspond to the activation level of the L2 Mandarin sublexical representation which are again assumed to be proportional to the tone pronunciation correspondences between Cantonese and Mandarin. The percentages shown below the L2 Mandarin phonological representations are assumed to be the activation level of those L2 Mandarin phonological representations using the sublexical route and represent the multiplication of activation of the corresponding L2 Mandarin onset, rime and tone.

Figure 3. L2 Mandarin word production model incorporating the tone component
For regular-tone words (e.g., 找 ‘find’), the correct tone (i.e., Mandarin tone 3) is strongly activated (as well as the correct L2 Mandarin phonological representation /zhao3/) due to the dominant tone correspondence (i.e., Mandarin tone 3). For irregular-tone words (e.g., 帽 ‘hat’), the correct tone (i.e., Mandarin tone 4) is only weakly activated since the L2 Mandarin phonological representations involve the subordinate tone correspondence while those L2 Mandarin phonological representations involving the dominant tone correspondence (i.e., Mandarin tone 3) are strongly activated. Therefore, Cantonese speakers may mistakenly think that ‘irregular-tone’ words where the Mandarin tone pronunciation does not follow the dominant pronunciation relationship are pronounced in Mandarin with the dominant correspondence (i.e., tone 3).

A Mandarin character-sound matching task using words which either employed a dominant (i.e., regular) or subordinate (i.e., irregular) tone relationship was carried out to examine whether the processing of Mandarin tones by Cantonese speakers was influenced by such relationships (Chu & Taft, 2011a). Cantonese learners of Mandarin had to decide by button-press whether a Mandarin pronunciation heard over headphones matched a visually presented Chinese character. The auditory stimulus either matched or mismatched its corresponding character in terms of its tone. For irregular-tone words (e.g., 帽 ‘hat’ mao4), the tone-mismatched pronunciation (e.g., mao3) was the pronunciation that Cantonese speakers would give if they were to apply the major tone corresponding rule. For regular-tone words (e.g., 找 ‘find’ zhao3), the tone of the mismatched pronunciation was the same as that of the correct pronunciation of the irregular word (e.g., zhao4). This was to make sure that the pair of tone contrast for the matched and mismatched pronunciation (e.g., Mandarin tone 3 vs. 4) was the same for the regular and irregular-tone words and that L1-L2 tone regularity was therefore the only difference between the two conditions. In order to avoid participants focusing solely on the tones when making their judgments, however, additional Chinese characters were chosen as distractors where the auditory stimulus for half of the distractors had a matched Mandarin pronunciation while the other half had a completely different Mandarin pronunciation (i.e. mismatched in both segments and tones).

Results indicated that more ‘yes’ responses were observed for regular- than irregular-tone words for the ‘matched’ condition. Furthermore, in the ‘mismatched’ condition, more erroneous ‘yes’ responses were observed for irregular- than regular- Mandarin tone words, thus demonstrating the influence of the L1-L2 tone pronunciation correspondence on Cantonese speakers’ knowledge of Mandarin words. The findings indicate that the processing of tones in an L2 is influenced by the L1 lexical system and support the L2 Mandarin word production model incorporating the tone component. It should be noted that the findings cannot be explained by mere negative transfer from the native phonological system, as all pairs of tone contrasts chosen for the matched and mismatched pronunciation (e.g., Mandarin
tone 3 vs. tone 4) were those which Cantonese speakers do not generally confuse perceptually (So & Best, 2010).

**Further evidence for the use of the sublexical route in L2 Mandarin word production**

The proposed sublexical route based on pronunciation relationships between Cantonese and Mandarin onset and rime in the L2 Mandarin production model was based on post-hoc evidence from Cantonese speakers’ production errors. In order to test the involvement of the sublexical route in L2 Mandarin word production directly, a Mandarin pinyin transcription task was carried out (Chu & Taft, 2011b) using words which either employed a dominant (i.e. regular) or subordinate (i.e. irregular) correspondence in relation to the three different sublexical units (i.e., onset, rime and tone). Examples of regular- and irregular- onset, rime and tone words are shown in Table 4. The regular and irregular words were matched on Cantonese sublexical pronunciation, stroke numbers and word frequency. Cantonese learners of Mandarin were shown Chinese characters in a questionnaire format and were told to write down the Mandarin pronunciations (i.e., onsets, rimes and tone) in pinyin. Results showed that more transcription errors were found for irregular than regular words for all sublexical units. In addition, the source of errors for irregular words was mostly due to the inappropriate application of the dominant pronunciation relationships. The data thus reveals a regularity effect in onset, rime and tone in the phonological knowledge of L2 Mandarin words by Cantonese speakers, supporting the use of the sublexical route in L2 Mandarin word production.

<table>
<thead>
<tr>
<th>Table 4. Examples of regular and irregular words</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sublexical unit</strong></td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Onset</td>
</tr>
<tr>
<td>Rime</td>
</tr>
<tr>
<td>Tone</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

However, it turns out that most of the regular onset and rime words had the same (i.e., congruent) pronunciation in Mandarin as in Cantonese, while most of the irregular words had a different (i.e. incongruent) pronunciation from Cantonese. For example, the word 對 ‘correct’ (pronounced deoi3 in Cantonese and dui4 in Mandarin) has the same onset /d/ in both Cantonese and Mandarin, so in addition to being regular, it is also a ‘congruent-onset’ Mandarin word for Cantonese speakers. In contrast, the irregular word 突 ‘sudden’ (pronounced dat6 in Cantonese and tu1 in Mandarin) is an ‘incongruent-onset’ Mandarin word for Cantonese speakers since its Mandarin onset /t/ is a different phoneme from Cantonese onset /d/. As most of the words used in the above transcription task were either
‘regular-congruent’ or ‘irregular-incongruent’ words, what was seemingly a regularity effect may actually have been a congruency effect. The transcription errors may simply be due to the negative phonological transfer from L1 into L2 rather than the inappropriate application of the dominant pronunciation relationships.

In order to tease apart regularity from congruency, Cantonese speakers’ phonological knowledge of Mandarin words was re-examined using ‘regular-incongruent’ and ‘irregular-congruent’ onset and rime words instead (Chu & Taft, 2011b), as seen in Table 5. For example, the Chinese word 旗 ‘flag’ is a regular-incongruent onset word because its Mandarin onset /q/ has a dominant pronunciation relationship (50% correspondence) with the Cantonese onset /k/, but is a different phoneme. On the other hand, 靠 ‘rely’ is an irregular-congruent onset word as the Mandarin onset /k/ has a non-dominant pronunciation relationship (15% correspondence) with Cantonese, despite being the same phoneme. The relative contribution of regularity and congruency effect can be examined by comparing the error rates of regular-incongruent and irregular-congruent words.

Table 5. Examples of regular-incongruent and irregular-congruent words

<table>
<thead>
<tr>
<th>Sublexical unit</th>
<th>Cantonese pronunciation</th>
<th>Regular-incongruent word</th>
<th>Irregular-congruent word</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandarin pronunciation (correspondence)</td>
<td>Example</td>
<td>Mandarin pronunciation (correspondence)</td>
<td>Example</td>
</tr>
<tr>
<td>Onset k</td>
<td>q (50%) 旗 ‘flag’</td>
<td>k (15%) 靠 ‘rely’</td>
<td></td>
</tr>
<tr>
<td>Rime ei</td>
<td>i (77%) 技 ‘skill’</td>
<td>ei (17%) 備 ‘prepare’</td>
<td></td>
</tr>
</tbody>
</table>

Result of the transcription task showed no difference in error rates between the two conditions in terms of their onsets, but more errors for irregular-congruent than regular-incongruent rime words. This higher error rate shows that Cantonese speakers’ phonological knowledge of Mandarin rime is mainly due to regularity rather than congruency. The non-significant difference in error rates between regular-incongruent and irregular-congruent onset words may seem to indicate that there is neither a regularity nor congruency effect. However, as the previous transcription task showed that the error rate is higher for irregular (i.e. irregular-incongruent) than regular (i.e., regular-congruent) words, we propose that both regularity and congruency exert an effect on the production of Mandarin onset by Cantonese speakers, and that they counterbalance each other when the error rates of irregular-congruent and regular-incongruent onset words are compared. It should be noted that a 2x2 design directly testing for a main effect of regularity and congruency is theoretically impossible. This is because a pair of congruent words differing only in regularity or a pair of regular or irregular words differing only in congruency do not exist by definition. For each Cantonese onset, there is only one congruent pronunciation in Mandarin and that Mandarin pronunciation can either have a regular or irregular relationship with the Cantonese onset, but not both. Using the Cantonese onset /k/ as an example, the Mandarin
onset /k/ has an irregular pronunciation relationship with its Cantonese counterpart (15% correspondence). Therefore, it is impossible to find a congruent but ‘regular’ pronunciation with the Cantonese onset /k/. Similarly, the Mandarin onset /d/ has a regular and congruent pronunciation relationship with the Cantonese onset /d/ (96% correspondence). Therefore, by definition, it is impossible to find a congruent but ‘irregular’ pronunciation with the Cantonese onset /d/.

Figure 4 illustrates a further revision to the L2 Mandarin word production model incorporating the onset congruency effect. In the original model, the activation from the L1 Cantonese sublexical representation /k/ to the L2 Mandarin sublexical representations /q/ and /k/ are assumed to be determined by the pronunciation correspondence between Cantonese and Mandarin (i.e., 55% and 15% respectively). It is now argued that the L2 Mandarin sublexical representation /k/ receives extra activation from the L1 Cantonese sublexical representation /k/ due to the fact that they are pronounced the same in both languages. The extra activation from the congruent pronunciation in L1 is justified by research showing that the L1 phonological representation, as well as its sublexical units, is also activated when bilinguals are asked to pronounce a word in their L2 (Costa, Caramazza, & Sebastian-Galles, 2000; Janssen, 1999). As a result, the activation level of the L2 Mandarin phonological representations kao4 and kao3 for the irregular-congruent onset word 靠 ‘rely’ exceeds its original activation through sublexical pronunciation correspondence, and the activation level of the L2 Mandarin phonological representations kei2 and kei1 for the regular-incongruent onset word 旗 ‘flag’ exceeds its original activation through sublexical correspondence. The exact amount of extra activation contributed from the onset congruency effect requires further investigation. Congruency may also exert extra activation on L2 rime units, but its influence

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**Figure 4. L2 Mandarin word production model incorporating the onset congruency effect**
may not be as strong as that of the congruent onset due to the subordinate and less prominent position in the syllable of the rime. Hence, the extra activation for the congruent rime is not strong enough to counterbalance the irregularity disadvantage for the irregular-congruent rime.

**Evidence for the use of the sublexical route in L2 Mandarin word recognition**

It is well known that the recognition of L2 words is influenced by the L1 phonological system (Broersma & Cutler, 2011). As in L2 Mandarin word production, we propose that the recognition of L2 Mandarin words by Cantonese speakers is also influenced by the pronunciation correspondences between Mandarin and Cantonese. Figure 5 illustrates the proposed L2 Mandarin word recognition model which makes use of the same conceptual, phonological and sublexical representations as in the L2 Mandarin word production model. It should be noted that this time the input is Mandarin (depicted at the top) as opposed to the production model where the output is Mandarin (depicted at the bottom). In this L2 Mandarin word recognition model, the concept route directly activates the concept through the L2 Mandarin phonological representation while the lexical route activates the concept through the L1 Cantonese phonological representation. The sublexical route activates the concept through the mediation of the L2 Mandarin and L1 Cantonese sublexical representation. The percentages shown between the L2 Mandarin and L1 Cantonese sublexical representation are the activation level of the L1 Cantonese sublexical representations which are assumed to be proportional to the pronunciation correspondence between Mandarin and Cantonese. The percentages shown under the L1 Cantonese phonological representations are assumed to be the activation level of those representations using the sublexical route, being the multiplication of the activation of the corresponding L1 Cantonese onset, rime and tone.

Figure 5. L2 Mandarin word recognition model
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Using the irregular-tone word 魔 ‘devil’ as an illustration, the Cantonese pronunciation is *mo1* and the Mandarin pronunciation is *mo2*. As proposed in relation to word production, beginning Cantonese learners of Mandarin might primarily use the sublexical route in recognizing Mandarin words while advanced learners use the lexical and concept route instead. So, when the beginning learners hear the Mandarin pronunciation *mo2*, the concept 磨 ‘grind’ is expected to be the most highly activated word candidate while the correct concept 魔 ‘devil’ is not activated at all based on the sublexical activation through L1 Cantonese phonological representation. On the other hand, upon hearing the mispronounced version *mo1*, the correct concept ‘devil’ is the most strongly activated candidate. Therefore, it is expected that beginning Cantonese learners of Mandarin can understand the intended word from the mispronounced version better than the correctly pronounced version. For more proficient Cantonese learners of Mandarin, as they gradually shift to the lexical and concept route in recognizing L2 Mandarin words, it is expected that their ability to understand the intended word from the correctly pronounced version will improve. However, if the sublexical route is not used by proficient Cantonese learners of Mandarin, their ability to understand the intended word from the mispronounced version should deteriorate.

A disyllabic word transcription task was carried out to test these predictions of the L2 Mandarin word recognition model (Chu & Taft, 2011c). Cantonese listeners with different L2 Mandarin phonological proficiency heard a mispronounced (e.g., *mo2gui3*) or correctly pronounced (e.g., *mo1gui3*) version of words (e.g., 魔鬼 ‘ghost’) spoken by a native Mandarin speaker. They were, however, told that the speaker was from a Cantonese background and were asked to guess the intended words spoken by the speaker if they heard any mispronunciations. Results showed that beginning Cantonese learners of Mandarin understood the mispronounced words better than the correctly pronounced words. For advanced Cantonese learners of Mandarin, recognition accuracy from the correct pronunciation was higher than that of less experienced learners, but their ability to understand the mispronounced word did not deteriorate. The latter result does not fit the proposed model where advanced Cantonese learners of Mandarin gradually shift from the use of the sublexical to lexical/concept route in recognizing L2 Mandarin words.

To account for this phenomenon, we argue that the L2 word recognition mechanism is different from the L2 word production mechanism with regard to the use of the sublexical route. With increasing L2 Mandarin proficiency, the connection between the L2 Mandarin phonological representation and the concept get strengthened as in the L2 word production model, while the sublexical route does not get weakened. The sublexical route is still used by Cantonese speakers in generating possible word candidates. For advanced learners, the word activated via the concept/lexical route from the mispronunciation *mo1* (e.g., 摸 ‘touch’) is incompatible with the second syllable of the compound word (*gui3*) and hence it is deactivated. On the other hand, the word activated via the sublexical route of this
mispronunciation mo1 (e.g., 魔 ‘devil’) is compatible with the second syllable, forming a meaningful word (e.g., 魔鬼 ‘ghost’) and hence it gets more activated. Thus, Cantonese speakers’ ability to understand a mispronounced word does not deteriorate with increasing L2 Mandarin proficiency.

**Conclusion and future research**

Developed on the basis of the above empirical findings, the three-route L2 Mandarin word production and recognition model can be summarized in the following way. Three routes are used by Cantonese speakers in producing and recognizing L2 Mandarin words: Concept, lexical, and sublexical. The concept route links the concept and the correct L2 Mandarin phonological representation directly, whereas the lexical route links the concept and the correct L2 Mandarin phonological representation through the L1 Cantonese phonological representation. The lexical route is maintained in the model to account for the Mandarin mispronunciations by Cantonese speakers due to negative homophonic transfer from Cantonese. As in Kroll and Stewart (1994), both a concept and lexical route is needed to account for developmental changes where beginning L2 learners rely on the lexical link in L2 word production because of the weak connection between the concept and the L2 phonological representation. Different from Kroll and Stewart (1994), the additional sublexical route proposed in this model activates the concept and L2 Mandarin phonological representation through L1-L2 onset, rime and tone pronunciation correspondence. Apart from the activation arising from L1-L2 Cantonese pronunciation correspondence, the L1 Cantonese onset also sends extra activation to the L2 Mandarin onsets with the same pronunciation. Concerning Cantonese speakers with different L2 phonological proficiency, beginning learners mainly use the sublexical route in both L2 Mandarin word production and recognition. Advanced learners gradually shift from the sublexical to lexical/concept route in producing Mandarin words while both routes are still in active use to generate possible word candidates in L2 Mandarin word recognition.

The current L2 Mandarin word production and recognition model has been developed mainly on the basis of off-line tasks (i.e., word transcription, Mandarin pinyin transcription, and character-sound matching). The involvement of the use of the sublexical route in L2 Mandarin word recognition can be further examined using on-line methods such as eyetracking and neuroimaging. Eye-tracking allows examination of the time course of the activation of different word candidates by using the visual-world paradigm where participants listen to a spoken sentence or word and then see four different words on the screen at the same time (e.g., Huettig & McQueen, 2007). The proportion of fixations on different words at different points of time is assumed to reflect the amount of activation for those words at that time. Applying this paradigm to test our recognition model, we hypothesize that the word 磨擦 ‘friction’ (pronounced mo4caat3 in Cantonese and mo2cai4 in Mandarin) will have a
higher activation and attract more fixations than the word 魔鬼 ‘ghost’ by Cantonese listeners upon hearing the first syllable of the Mandarin pronunciation mo2gui3 using the sublexical route. However, upon hearing the second syllable, Cantonese listeners are hypothesized to shift their attention to the word 魔鬼 ‘ghost’ as the Chinese character 磨 ‘grind’ cannot be combined with the second syllable gui3 to form a meaningful word. Without the involvement of the sublexical route, the activation of the word 磨擦 ‘friction’ would not be expected.

Using event-related potential (ERP), the recognition model can also be tested using the N400 effect which is an indicator of semantic violation (e.g., Schirmer, Tang, Penney, Gunter, & Chen, 2005). Semantic violation occurs when a sentence with incompatible meanings is processed. A larger N400 effect is observed when an incongruent sentence (e.g., The man is cooking with a wall.) is processed as opposed to a congruent sentence (e.g., The man is cooking with a pan.) Based on the model, it is expected that a larger N400 effect will be observed when beginning Cantonese learners of Mandarin hear the correctly pronounced Mandarin version (e.g., mo2gui3) when compared with the tone-mispronounced version (e.g., mo1gui3) of an irregular tone word (e.g., 魔鬼 ‘ghost’). This is because the most highly activated word candidate (e.g., ‘grind’) generated using the sublexical route from the correctly pronounced version (e.g., mo2) cannot be combined with the second syllable (e.g., gui3) to form a meaningful word. In contrast the most highly activated word candidate (e.g., ‘devil’) generated from the mispronounced version (e.g., mo1) can.

In addition, the current model has a potential to be implemented computationally using a large corpus of monosyllabic and multisyllabic Mandarin production data collected from many Cantonese speakers with different levels of L2 Mandarin phonological proficiency in standardized Mandarin testing. The computational model can then be used to simulate the behavioral findings reported in this paper. It can also be used to examine the relative contribution of regularity and congruency in L2 Mandarin word production.

In sum, a promising L2 Mandarin word production and recognition model has been proposed in this paper to account for Mandarin production and recognition data observed from native Cantonese speakers. In the future, the model can be further applied and tested in the behavioral, neurolinguistics, and computational domain.

References


