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The Effect of Musical Aptitude: Perceiving and Producing Mandarin Lexical Tones

By

Non-Native Speakers of Chinese

Jingzhi (Julie) Zhu

Abstract

This study explores the effect of musical aptitude as a combination of innate musical aptitude and learned/trained musical aptitude in tonal perception and tonal production by non-native speakers of Chinese. The study aims to discover whether the musical aptitude of non-native speakers of Chinese helps in their perception and production of Mandarin lexical tones at different stages of learning.

Mandarin uses tones to lexically distinguish word meanings, and therefore learning these tones is essential to communication in the language. A number of studies have found that those learning Mandarin as a foreign language have difficulty in perceiving and producing Mandarin lexical tones (Klein, Zatorre, Mikner & Zhao, 2001; Wang et al., 2001a; 2003; Lee et al., 2009). In order to tackle this problem and therefore improve Mandarin learners’ learning, researchers have attempted to detect the source of this difficulty. Seven factors were identified, three linguistic factors and four sociolinguistic factors. The former included the categorical nature of tone, the phonetic cues for tone, and the context-dependent nature of tone sandhi; the latter factors included the learners’ language experience in the form of bilingualism, the learner’s age, foreign language anxiety and the impact of gender (Chao, 1968; Brown, 1980; Hassler et al., 1985; Xu, 1997; Peretz & Coltheart, 2003; Wee, 2008). Among the seven factors, the phonetic cues of Mandarin lexical tones and learners’ learning experience in the form of bilingualism remained underspecified in prior studies, and hence became two of the research aims in this study. The findings of the small body of research into another underspecified factor affecting learners’ perception and production of Mandarin lexical tones, learners’ musical aptitude, have been inconsistent: some investigators found little or no relationship between musical
aptitude and L2 learning of tone (e.g. Peoppel, 2001; Anvari et al., 2002), while other investigators have found such a relationship to exist (e.g. Zatorre et al., 2002; Slev & Miyake, 2006; Wong et al., 2007).

In order to provide more conclusive evidence in regard to the three above mentioned underspecified factors affecting learners’ perception and production of Mandarin lexical tones, the current study provides a more rigorous and precise research design than those adopted in previous studies. During the first stage of the longitudinal study forty-five non-native speakers of Chinese enrolled in the Chinese Stage I course at the University of Auckland were administered a questionnaire, and then tested using an innate MA test, a Mandarin lexical tone listening test (for perception), and a Mandarin lexical tone speaking test (for production). The eleven participants who continued into the later stage of the study again took each of these tests twelve weeks later at the end of their first semester of study.

A comparison of the findings of the tests revealed that musical aptitude, defined as a combination of innate musical aptitude and learned/trained musical aptitude, did help non-native speakers of Chinese in their perception and production of Mandarin lexical tones in the early stage of their learning. Particularly, pitch in musical aptitude provided the most advantage in learners’ tonal perception, and melody in musical aptitude provided the most advantage in their tonal production. Concurrently, in addition to musical aptitude, learners’ language experience in form of bilingualism also played a role in their tonal perception and production. However, the findings also revealed that as learners’ tonal training in the formal classroom setting increased, the impact of observed musical aptitude on learners’ tonal perception and production became less over time. These findings overall indicate that while musical aptitude
may help non-native speakers of Chinese in their perception and production of Mandarin lexical tones during the early stage of their learning, it may not necessarily be as important during the later stages of their learning.

This thesis concludes with important insights and significant theoretical, methodological, and pedagogical contributions from this research on the relationship between musical aptitude and Mandarin tones.
Acknowledgements

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<td>MA</td>
<td>Musical aptitude</td>
</tr>
<tr>
<td>ME</td>
<td>Musical experience</td>
</tr>
<tr>
<td>MLT</td>
<td>Mandarin listening test</td>
</tr>
<tr>
<td>MST</td>
<td>Mandarin speaking test</td>
</tr>
<tr>
<td>LE</td>
<td>Language experience</td>
</tr>
<tr>
<td>L1</td>
<td>First language</td>
</tr>
<tr>
<td>L2</td>
<td>Second language</td>
</tr>
<tr>
<td>L3</td>
<td>Third language</td>
</tr>
<tr>
<td>TLS</td>
<td>Tonal language speakers</td>
</tr>
<tr>
<td>NTLS</td>
<td>Non-tonal language speakers</td>
</tr>
<tr>
<td>NNS</td>
<td>Non-native speakers</td>
</tr>
<tr>
<td>NS</td>
<td>Native speakers</td>
</tr>
<tr>
<td>BS</td>
<td>Bilingual speakers</td>
</tr>
<tr>
<td>MS</td>
<td>Monolingual speakers</td>
</tr>
<tr>
<td>KS</td>
<td>Korean speakers</td>
</tr>
<tr>
<td>ES</td>
<td>English speakers</td>
</tr>
<tr>
<td>T0</td>
<td>Neutral tone</td>
</tr>
<tr>
<td>Code</td>
<td>Term</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>T1</td>
<td>The first tone</td>
</tr>
<tr>
<td>T2</td>
<td>The second tone</td>
</tr>
<tr>
<td>T3</td>
<td>The third tone</td>
</tr>
<tr>
<td>T4</td>
<td>The fourth tone</td>
</tr>
<tr>
<td>F0</td>
<td>Fundamental frequency</td>
</tr>
<tr>
<td>RQ</td>
<td>Research question</td>
</tr>
<tr>
<td>UoA</td>
<td>University of Auckland</td>
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</table>
Chapter 1: Introduction and Literature Review

1.1. Overview of the chapter

Mandarin Chinese is a lexical tone language which exploits pitch differences to reflect the lexical meaning of a word (Chao, 1968; Yip, 2002; Duanmu, 2007). Therefore learning Mandarin tone is as essential to communication in the language as consonants and vowels are in the English language. A number of studies have found that non-native speakers of Chinese have difficulty in learning Mandarin lexical tones. Various factors including linguistic factors and sociolinguistic factors contributing to the learning difficulty were discovered (e.g. Klein, Zatorre, Mikner & Zhao, 2001; Wang et al., 2001a; 2003; Lee et al., 2009). The present research has explored another underspecified factor—the learners’ musical aptitude. The effect of musical aptitude (MA) in tonal perception and production by non-native speakers (NNS) of Chinese was investigated in the present study. In other words, the study has examined whether the MA of NNS helps in the perception and production of Mandarin lexical tones at different stages of their learning, where the relationship between learners’ MA and their tonal perception, as well as between their MA and tonal production, will be examined at two stages of testing. Hence, this introductory chapter provides the background to the thesis by first revealing the importance of Mandarin in general and Mandarin lexical tones in particular in Chinese language. Subsequently, the literature review is divided into two parts: by reviewing seven factors contributing to the perception and production of Mandarin lexical tones, section 1.4 evaluates prior studies on the learning of Mandarin tones by NNS, followed by an overall discussion of section 1.4. On the other hand, section 1.5 of the chapter goes on to examining prior studies on the relationship between music and language, by initially discussing
the definition of musical aptitude, and then examining the relationship between music and language in general, and more specifically between musical aptitude and tonal features of languages, as well as between musical aptitude and Mandarin lexical tones in particular. Furthermore, section 1.5 highlights the relationship between learners’ musical experience and the learning of Mandarin tones, as well as between learners’ tonal learning experience/tonal training and their learning of Mandarin tones. Concurrently, the studies which do not clearly support a link between music and language are reviewed, followed by an overall discussion of section 1.5. The final section summarizes the chapter, and explains the research aim for the thesis and its structure.

1.2. The importance of Mandarin in Chinese language

The Chinese language is a group of related but in many cases mutually unintelligible language varieties, forming a branch of the Sino-Tibetan language family (Wu, 1992; Hu et al., 2000). The varieties of Chinese are usually described by native speakers (NS) as dialects of a single Chinese language, but linguists note that they are as diverse as a language family (Cao, 1990; Jin, 2002; Jin, 2007). There are between 7 and 13 main regional groups of Chinese (depending on the classification scheme), of which the most common classification is 7. These seven groups are classified as the Northern group, the Wu group, the Xiang group, the Gan group, the Kejia group, the Min group, and the Yue group (Hu et al., 2000), and each of these groups has its own dialects/varieties of Chinese language. Specifically, Standard Mandarin Chinese (i.e. Putonghua/Guoyu/Huayu/Hanyu) is dominantly spoken in the Northern group, and is the most standardized form of spoken Chinese based on the Beijing dialect of Mandarin Chinese (Hu et al., 2000; Zhao, 2000; Shao, 2010). Standard Mandarin is the official language of China and Taiwan, one of four official languages of Singapore.
and is one of the six official languages of the United Nations. Kratochvil (1968) notes that there are 7,000 languages in the world: some are spoken by a handful of individuals, and one, standard Mandarin Chinese, by hundreds of millions. The written form of Standard Mandarin (i.e. 中文; Zhōngwén), based on the morphosyllabic symbols known as Chinese characters (i.e. 汉字/漢字; hànzi), is shared by literate speakers of otherwise unintelligible dialects. Although the terms such as ‘Chinese’ and ‘Mandarin’ are acknowledged to be imprecise to illustrate ‘Standard Mandarin Chinese’, the term ‘Mandarin’ here will be used to mean ‘Standard Mandarin’ in this thesis.

1.3. The importance of Mandarin lexical tones

Mandarin is a lexical tone language which exploits pitch differences to reflect the lexical meaning of a word (Chao, 1968; Yip, 2002; Duanmu, 2007). Therefore learning Mandarin tone is as essential to communication in the language as are consonants and vowels in the English language. A number of studies have found that those learning Mandarin as a foreign language have difficulty in perceiving and producing Mandarin lexical tones (Klein et al., 2001; Wang et al., 2001a; 2003; Lee et al., 2009). In order to investigate learners’ difficulties with Mandarin tones and therefore improve their learning, a number of studies (Klein et al., 2001; Wang et al., 2001a; 2003; Lee et al., 2009) have taken a comparative approach to explore the differences that exist in the perception and production of Mandarin tone by NS and NNS of Mandarin. By reviewing the existing relevant literature, seven key factors affecting learners’ Mandarin tonal perception and production have been found in section 1.4 immediately below. These factors are divided into three linguistic factors and five sociolinguistic factors, where three linguistic factors include the categorical
nature of tone, the phonetic cues for tone and the context-dependent nature of tone sandhi, and four sociolinguistic factors which include learners’ language experience (LE) in the form of bilingualism, learner’s age, foreign language anxiety and the impact of gender (Chao, 1968; Brown, 1980; Hassler et al., 1985; Xu, 1997). These seven factors with respect to the learning (i.e. perception and production) of Mandarin lexical tones, are illustrated in detail in section 1.4.

1.4. The Learning of Mandarin Lexical Tones
This section reviews the significant prior studies in relation to the learning of Mandarin lexical tones. Particularly, perception and production of Mandarin lexical tones will be investigated in this study. Hence, this section starts with a definition of perception and production, followed by a review of the detected seven key factors impacting on the perception and production of Mandarin lexical tones by NNS of Chinese. The three linguistic factors, which are the categorical nature of tone, the phonetic cues for tone, and the context-dependent nature of tone sandhi, are examined first. Subsequently, a review of previous research is undertaken on the other four sociolinguistic factors including learners’ language experience in the form of bilingualism, tonal learning experience/tonal training, age, foreign language anxiety and the impact of gender. Before introducing these seven factors contributing to learners’ perception and production of Mandarin lexical tones, perception and production need to be defined first. This is done immediately below.

1.4.1. Perception and production
Speech perception is the process by which the sounds of language are heard, interpreted and understood. Research in speech perception seeks to understand how human listeners recognize speech sounds and use this information to understand
spoken language. The process of perceiving speech begins at the level of the sound signal and the process of audition. After processing the initial auditory signal, speech sounds are further processed to extract acoustic cues and phonetic information, and finally assign the signal to the phonology. This speech information can then be used for higher-level language processes, such as word recognition (Nygaard and Pisoni, 1995; Wang, 2003). Hence, the one focus in this study is the process of listening to Mandarin lexical tones.

Language production is the production of spoken or written language. It describes all of the stages between having a concept, and translating that concept into a linguistic form. The basic loop occurring in the creation of language consists of the following stages: Intended message → Encode message into linguistic form → Encode linguistic form into speech [motor system] → Sound goes from speaker's mouth to hearer's ear [auditory system] → Speech is decoded into linguistic form → Linguistic form is decoded into meaning (Carroll and Stutterheim, 2003; Wang and Sereno, 2003). Hence, the other focus in this study is the articulation of Mandarin lexical tones. The following sub-sections examine the three linguistic factors, followed by the four sociolinguistic factors contributing to NNS’ perception and production of Mandarin lexical tones.

1.4.2. Three Linguistic Factors

The three linguistic factors, found to affect Mandarin learners’ tonal perception and production, are the categorical nature of tone, the phonetic cues for tone, and the context-dependent nature of tone sandhi.
1.4.2.1. The categorical nature of tone

Mandarin lexical tone is categorical (See section 1.4.2.1.2) (Chao, 1968; Wu & Lin, 2008; Yang, 2010). Before examining this source of difficulty for Mandarin learners, Mandarin syllable structure and tonal categories need to be clarified.

1.4.2.1.1. The Mandarin syllable structure

Although Western linguists utilize units/components called onset, nucleus and coda to describe a syllable (Ladefoged, 2001; Brown, 2010), many modern Chinese linguists adopt the traditional Chinese approach to describe Mandarin syllables as composed of initials and finals (Zhang, 1986). Although both approaches are equally easy to learn and apply, the traditional Chinese approach will make this study more accessible to those linguists and teachers who primarily work with Mandarin (Zhang, 1986).

Table 1.1 Mandarin Syllable Structure

<table>
<thead>
<tr>
<th>Initial</th>
<th>+</th>
<th>Final</th>
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<tr>
<td>(C)</td>
<td>V</td>
<td>(V)</td>
</tr>
<tr>
<td>a) n [n]</td>
<td>i [i]</td>
<td>(V)</td>
</tr>
<tr>
<td>b) zero</td>
<td>e [ɯə]</td>
<td></td>
</tr>
<tr>
<td>c) l [l]</td>
<td>a</td>
<td>i [aɪ]</td>
</tr>
<tr>
<td>d) x [ɕ]</td>
<td>i</td>
<td>a</td>
</tr>
<tr>
<td>e) c [ʦʰ]</td>
<td>a</td>
<td>n[an]</td>
</tr>
</tbody>
</table>

In the traditional Chinese schema, each syllable is composed of two parts: an initial and a final which constitute its segmental structure (see Table 1.1 above). However, an initial is not obligatory in a Mandarin syllable such as b in Table 1.1. Hence, the initial phoneme is either a consonant (C) or zero/none; the final phoneme(s) of the syllable is open to everything else, which could be a single vowel (V) (monophthong) (see a in Table 1.1), double Vs (diphthong) (see c in Table 1.1), triple Vs (triphthong) (see d in Table 1.1), or the combination of a V and a C (see e in Table 1.1).
1.4.2.1.2. Mandarin lexical tonal categories

It is debatable whether there was a phonemic tonal distinction in Ancient Chinese dating back to 2000 years ago. A growing amount of evidence points to the possibility that the tonal distinctions as attested in Middle Chinese were a later development following the loss of distinct segmental features of certain syllable types in Ancient Chinese (Yang, 2010). Modern Mandarin contains four citation tonal categories: level, rising, dipping and falling, as well as a fifth tone, called the neutral tone (Chao, 1968). Every full (stressed) syllable carries a lexical tone (Chao, 1968), whereas weak (unstressed) syllables are atonic. The weak (unstressed) syllables could serve as grammatical markers or suffixes; there are also lexically marked neutral tones (See Figure 1.2) (Chao, 1968). The pitch contours of the four full tonal categories are represented in Chao’s tone-letter system (1968), which divides a pitch scale into five distinct levels, ranging from point 1 (the lowest) to point 5 (the highest). These points are relative rather than absolute, and low and high have to do with a person’s normal pitch range (Chao, 1968). Specifically, Figure 1.1 shows that

(1) The first tone (T1) (i.e. level tone), high-level [55] (level tone), starts near the top of a speaker’s pitch range and continues on that level to the end;

(2) The second tone (T2) (i.e. rising tone), high-rising [35], starts at mid-range and rises to the top of the range;

(3) The third tone (T3), (i.e. dipping tone) low-dipping [214], starts at below mid-range, dips to the lowest pitch, and rises above mid-range;

(4) The fourth tone (T4), (i.e. falling tone) high-falling [51], starts near the top of the range and falls toward the bottom.
As presented in Figure 1.1, the sequence ma with four different tones represents four different lexical items (i.e. ma [T1] = mother; ma [T2] = hemp; ma [T3] = horse; ma [T4] = scold/blame).

Figure 1.1  Y. R. Chao’s tone-letter notation (1968)

Apart from the four lexical tones described above, the pitch contour of the fifth neutral tone is conditioned by the preceding syllable or sentence intonation (Dow, 1972; Cheng, 1973; Yang, 2010). Therefore, it is dynamic, psychological, relative and abstract, which cannot be measured by canonical shape. There are generally two types of neutral tone (i.e. T0): lexical neutral tone of which the underlying original tone carries the lexical meaning (see Figure 1.2) and grammatical neutral tone (Chao, 1968; Cheng, 1973; Duanmu, 1990). Lexical neutral tones will be included in this study.

(a) dongxi  
(i) [T1 T1] ‘east and west’
(ii) [T1 T0] ‘thing’

(b) duoshao (i) [T1 T3] ‘many and few’
(ii) [T1 T0] ‘how many’

(c) xiongdi (i) [T1 T4] ‘brothers’

For the (i)/(ii) lexical pairs found in Figure 1.2, the second syllable in each (i) word carries a full, underlying lexical tone, and as such, carries its full, underlying lexical meaning, i.e. ‘west’ in (a), ‘few’ in (b) and ‘brothers’ in (c). In contrast, the second syllable in each (ii) word carries the neutral T0, resulting in the original full meaning of that second syllable being weakened or lost altogether.
(ii) [T1 T0] ‘younger brother’

**Figure 1.2 Lexical neutral tones**

In view of the complexity of Mandarin lexical tonal categories and the foreignness of lexical tones for learners who are NNS of a tonal language, it is not difficult to see that the categorical nature of Mandarin lexical tone is difficult for NNS to perceive and produce. It has long been known that sounds that function as different categories in one language can be difficult for speakers of another language to discriminate (Goto, 1971). For instance, sounds 1 and 2 in language A are categorically distinct whereas for language B the sounds are not categorically distinctive. If native speakers of language B are attempting to learn language A, then it is extremely challenging for these learners to categorically discriminate between sounds 1 and 2 in language A. A number of comparative studies (e.g. Wang, 1967; Hallé et al., 2004; Bent, 2005; Xu et al., 2006; Wu & Lin, 2008; Yang, 2010) have consistently found that native listeners are able to distinguish a phonemic contrast categorically whereas non-native listeners are not.

These studies argue that the non-native listeners’ performance is best explained by their L1 (i.e. their first language)/native language phonology: If tones are part of the phonological system, they are perceived as phonemic categories; otherwise, they are perceived as non-linguistic melodic variations, which largely contribute to their learning difficulty. Specifically, by employing different language speakers including French, German, Italian, English and Dutch, Bent (2005), Leather (1987), Delogu et al. (2009) and Halle et al. (2004) achieved consensus that Mandarin Chinese listeners perceive lexical tones in a categorical way based on the phonological value of tone contours, whereas the aforementioned non-tonal speakers perceive them in a more
psychophysical way, finding it difficult to discriminate between them. The absence of categorical perception for lexical tones produces difficulties in tonal labeling, which suggested that these speakers’ labeling functions reflected unstable or linguistically inappropriate perceptual weighting (Leather, 1987).

However, the aforementioned studies also reveal that the impact of the L1/native language is not the only factor that affects categorical perception of lexical tones, but also included are linguistic experience, the nature of the acoustic cues, hemispheric impact, memory retention and other psychophysical factors. For instance, hemispheric-processing studies (e.g. Hsieh et al., 2001; Wang et al., 2001a) have consistently demonstrated that Mandarin tones are predominantly processed in the left hemisphere by native Mandarin speakers, whereas interestingly, native speakers of American English with no prior experience of a tone language did not show dominance of either hemisphere. These results suggest that left hemisphere dominance for the Mandarin speakers arose from the intrinsic linguistic significance of the F0 modulations (Wang et al., 2001b), which are categorical.

In sum, although Mandarin learners largely suffer from L1 interference, their tonal categorical perception/sensitivity could be trained through proficient tonal experience (Sereno & Wang, 2008). However, their learning difficulty will remain if they lack experience in processing the various phonetic features characterizing Mandarin tones, especially F0 features (to be discussed as follows).

1.4.2.2. Phonetic cues for tone

Phonetic studies on the understanding of acoustic characteristics of Mandarin lexical tones by NS have found that fundamental frequency (F0)/pitch, duration/length/time, and amplitude/loudness/intensity, turning point, ∆F0 as well as vowel height all constitute phonetic correlates and perceptual cues for tone (Lin et al., 1985; Chuang et
al., 1972; Moore & Jongman, 1997), with F0/pitch typically being the most important, while duration and amplitude are secondary (Liu, 1924; Howie, 1976; Wu, 1986; Jongman et al., 2002; Deng & Dang, 2007). Previous studies (e.g. Blicher et al., 1990; Huang, 2004; Bent, 2005; Ding et al., 2006) found that NNS perceive/produce these acoustic cues differently from NS. The differences in how these acoustic cues are used have an effect on non-native production and perception of Mandarin lexical tone, a factor which contributes to their learning difficulty. Before summarizing the differences in perception/production of Mandarin lexical tone between NNS and NS, the phonetic correlates of Mandarin lexical tone need to be introduced as follows.

1.4.2.2.1. **F0/Pitch**

F0/Pitch is the repetitive rate of sound waves/vibration of vocal folds that have the lowest value/rate (Yip, 2002). F0/pitch perception is the primary and the most important phonetic correlate of Mandarin lexical tones. Phonetic studies have examined the fundamental frequency contours of Mandarin Chinese tones (e.g., Liu 1924; Wang 1967; Dreher et al., 1969; Howie, 1970; Chuang, et al., 1972; Rumjancev, 1972; Moore & Jongman, 1997). These studies indicate that F0/pitch height (i.e. register) and F0/pitch contour are the primary acoustic parameters characterizing Mandarin tones. Gandour (1984) explored whether F0 height or F0 contour serves as a more important perceptual cue. His results suggest that while both dimensions are important, Mandarin listeners seem to attach slightly more importance to F0 contour than F0 height.

1.4.2.2.2. **Duration/Length/Time**

Duration indicates how long a certain pitch is sustained. In Mandarin, the duration/length of citation T3 [214], which mostly occurs as a phrase-final syllable, is the longest among the four (Dow, 1972; Cheng, 1973; Howie, 1976; Duanmu, 2007),
although the duration of its allophonic variant [21] (i.e. half citation T3) becomes similar in length to the other three tones. In addition, related to the time that a pitch is sustained is the time at which the pitch undergoes change. This aspect of duration is particular relevant to T2 and T3, as these tones exhibit similar contours. Therefore, T2 and T3 can be characterized in terms of two measures: Turning Point and ∆F0 (Moore & Jongman, 1997). Turning Point is the point in time at which the contour changes from falling to rising, and ∆F0 is the F0 change from the onset of the tone to the Turning Point (Deng & Dang, 2007). Tone 2 typically has an earlier Turning Point and smaller ∆F0 than Tone 3. Perception experiments have shown that these two measures are important cues for making a distinction between Tones 2 and 3 (e.g. Blicher et al., 1990; Shen & Lin, 1991; Shen et al., 1993; Moore & Jongman, 1997).

1.4.2.2.3. Amplitude/Loudness/Intensity

Amplitude as the perception of loudness indicates the size of the pitch differences in air pressure that occurs. The appropriate measure corresponding to loudness is acoustic intensity (Ladefoged, 2001). A syllable usually has higher amplitude when it occurs with a higher tone than it does with a lower tone (Duanmu, 2007). Chuang et al. (1972) showed that Tone 4 has the highest overall amplitude while Tone 3 has the lowest.

1.4.2.2.4. Vowel height & (de)voiced onset

Vowel height is another correlate of lexical tone. It is well known that high vowels are inherently higher in pitch than low vowels (Ladefoged, 2001; Duanmu, 2007). Besides, a murmured vowel usually has lower pitch contours than a non-murmured vowel (Yip 2002; Duanmu, 2007). There is a generalization that voiced onset consonants tend to co-occur with murmured vowels, which in turn tend to have lower
pitch, and voiceless onset consonants tend to co-occur with non-murmured vowels, which in turn have high pitch. The generalization has been called ‘voiceless-high and voiced-low’ (Duanmu, 2007).

Overall, we can see that the above phonetic correlates of Mandarin lexical tones are functionally integrated when Mandarin speakers identify the tones (Gandour, 1984; Massaro et al., 1985; Gårding et al., 1986; Blicher et al., 1990; Shen & Lin, 1991; Moore & Jongman, 1997). However, the primary acoustic correlate for lexical tone is F0/pitch, whereas amplitude and duration are secondary cues that contribute to the perception of tonal distinctions (Norman, 1987). Nevertheless, comparative studies have found that NNS of Mandarin perceive and produce these acoustic cues differently from NS, and how they perceive/produce these acoustic cues differently from NS are summarised as follows.

Some studies (e.g. Gandour, 1983; Shen, 1990; Wang et al., 2003) have explored the perception of Mandarin lexical tone. Gandour (1983; 1984) and Wang et al. (2003) share a general consensus that Mandarin listeners attach slightly more importance to F0 contour than F0 height, whereas English listeners, because English has no contrastive tones, or contours, direct their attention more to the height, and less to the contour dimension. Therefore, F0 height/register plays an important role in the perception of tones by NNS (Yang, 2010). As section 1.4.2.2.2 above indicates, duration and turning point are important cues in distinguishing T2 and T3. Deng and Dang (2007), and Blicher et al. (1990) have found that non-native learners have difficulty in identifying T2 and T3 in terms of duration and turning point: they often identify T2 as T3. Interestingly, Wu and Lin (2008) found that both Mandarin and English listeners perceived the T2/T3 contrast non-categorically. The inability of
Mandarin speakers to categorize this native tone contrast may have been caused by the partial loss of perceptual cues. It is noted that the synthesized T2 and T3 used in this controlled study retained the majority of the F0 information available in natural speech but the critical cues (i.e. duration and turning point) were intentionally removed and therefore not present in this controlled study. The study implies that duration and turning point are important in the identification of T2 and T3.

In addition to the studies discussed immediately above, other studies (e.g. Wang et al., 2003; Bent, 2005; Yang, 2010) have investigated the production of Mandarin lexical tone. First, Wang et al. (2003), Bent (2005), and Yang (2010) show that NNS have difficulty in producing pitch height. With some tones (e.g. T2, T3), NNS managed to produce the correct target pitch contour, but perhaps the onset or offset of that contour was not within native norms (Wang et al., 2003). They concluded that NNS production appears to be determined by the contour of the tones, which is in contrast with NS who utilise both the contour and height/register to determine tonal categories. In addition, Cheng (1974) and Ding et al. (2006) arrived at a similar conclusion when they found that German and English speakers have a much smaller f0 range than Chinese native speakers, and that German speakers have difficulty in changing pitch movement rapidly in a very short time because of the typical gradual pitch movement in German. The authors suggest that native speakers of a non-tonal language need to widen their pitch range to successfully acquire a tonal language such as Mandarin (Cheng, 1974).

1.4.2.2.5. Overall discussion of section 1.4.2.2 Phonetic cues

The previous studies tend to agree general consensus that NNS’ perception of tone is primarily determined by pitch height, whereas their production tends to be determined
by the contour of the tones (e.g. Gandour, 1983; Shen, 1990; Wang et al., 2003). In contrast, native Mandarin listeners attach slightly more importance to pitch contour than pitch height (Gandour, 1983; 1984; Wang et al., 2003), and native speakers utilise both the contour and height/register to determine tonal categories. However, these studies investigating how NNS and NS perceive and produce the phonetic cues of Mandarin lexical tone have compared and contrasted the F0/pitch height with pitch contour only. Little study so far has considered other acoustic cues, such as amplitude, to comparatively discover among the important acoustic cues which acoustic cue(s) has the strongest association with the Mandarin tonal perception and production respectively by NNS. Additionally, whether it was language perception or production or both that was/were assessed in each of the previous studies was not clearly stated. This is important as both are two separate dimensions of acquiring a foreign language. Moreover, most of the studies focused on tones in syntactic structure instead of monosyllables and disyllables. For these reasons, the present study will attempt to take into consideration all important phonetic cues which are pitch height, pitch contour, amplitude and duration in both the perception and production of Mandarin lexical tones in monosyllable and disyllable structures. The purpose of including the four acoustic cues of monosyllable and disyllable Mandarin lexical tones in both the perception and production dimensions is to comparatively discover whether NNS pay the most attention to the pitch height in the perception of Mandarin lexical tones, and whether NNS pay the most attention to the pitch contour in the production of Mandarin lexical tones. More specifically, by selecting the musical aptitude test responding to these four acoustic cues of Mandarin lexical tones (to be discussed in section 2.4.2.2 in Methodology Chapter), the current study will comparatively explore which aspect of musical aptitude has the most impact on or provides the most
advantage in learners’ tonal perception and production respectively. This will become one of five research aims in the current study, which will correspond to research sub-question #3 (See section 1.6). Doing this will allow us to evaluate whether or not the research results from the aforementioned prior studies are consistent with the results from the current study.

In sum, NNS’ learning difficulty is not only derived from the categorical tone and phonetic cues of Mandarin lexical tone, but also from the interpretation of tone sandhi rules\(^2\), which are discussed in the following sub-section.

1.4.2.3. **Context-dependent /tone sandhi**

All phonological descriptions of Mandarin have agreed on the existence of four distinctive tonal categories which can be observed in the citation forms of monosyllabic morphemes (Howie, 1976). However, linguistic tone production and perception is not absolute, but a dynamic relative matter (Cheng, 1973; Yip, 2002; Brown, 2010; Lee et al., 2010). In real life speech, the four tones of Mandarin are realized with variations, according, for example, to tone sandhi rules, different syntactic structures, stress, intonation, monolinguals/bilinguals, gender, age, geography, and speakers’ mood (Dow, 1972; Yip, 2002; Sanders, 2008). The dynamic representations of Mandarin lexical tone, which are inconsistent with the pre-described traditional tonal values as shown in Chao’s digit-letter pitch scale (Cheng, 1973; Howie, 1976; Sun, 1998), contribute to the source of difficulty for NNS in perceiving/producing Mandarin lexical tones. Tone sandhi that occurs in disyllables will be included in this study.

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\(^2\) Tone sandhi is when two or more syllables occur in combination, their tones may undergo change or one tone may affect the shape of an adjacent tone (Chao, 1968).
Some studies (e.g. Lin, 1985; Sun, 1998; Duanmu, 2007) investigated the production of context-dependent/tone sandhi rules. These studies show that the dynamic nature of tone sandhi at the lexical level—monosyllables and disyllables, reinforces the difficulty in producing Mandarin lexical tone by NNS. Broselow et al. (1987), and Peabody and Seneff (2004; 2006) found furthermore that when lexical tones are produced in isolation, their contours seem well defined and quite stable; when produced in context, however, the tonal contours undergo certain variations depending on the preceding and following tones. Similarly, some studies (e.g. Lin, 1985; Sun, 1998; Duanmu, 2007) show that when lexical tones are produced in isolation, their contours seem well defined and quite stable; when produced in context, however, the tonal contours, amplitude and duration undergo variations depending on the preceding and following tones.

Other studies (e.g. Lin, 1985; Broselow et al., 1987; Shen, 1989) explored the perception of tones presented in different sentence positions, which similarly reveals a reason for the difficulty NNS’s have in perceiving Mandarin lexical tone. Xu (1997), Huang and Holt (2009), and Lee et al. (2009) agree that the f0 contour of either tone in the sequence is substantially influenced by the surrounding tones. These influences are called carry-over effects (i.e. mostly assimilatory: the starting f0 of a tone is assimilated to the offset value of a previous tone) and anticipatory effects (i.e. mostly dissimilatory: a low onset value of a tone raises the maximum f0 value of its preceding tone). These studies explored the perception of tones presented in different syntactical structures, where the carry-over effects and anticipatory effects were addressed to highlight the importance of duration and amplitude in connected speech. Duration is also important in distinguishing T2 from T3 (Deng & Dang, 2007).
Broselow et al. (1987), and Lin (1985) found that the detectability of Tone 4 varied with its contextual position. That is, Tone 4 was the most easily identified of the four tones when presented in isolation, and in the final position of doublets and triplets. However, this identification declined dramatically in non-final position, and became the poorest in identifying Tone 4 among the four tones. The results reflected the interference from English intonation and stress which play a vital role in the quality of pronunciation. Mandarin tone 4 is acoustically similar to the unmarked pattern of declaratives (e.g. I love you!) at the end of an utterance in English, as both involve a falling pitch. Therefore, this tone is easy to perceive when it occurs sentence-finally since it corresponds to a familiar pattern in English. Additionally, Shen (1989) explains learners’ difficulty with level and falling tones as a result of interference from ‘the articulatory habits of English prosody,’ notably, stress. Each syllable in the utterance is pronounced with an ‘exaggerated’ full tone, particularly the syllable on which she/he believes the stress should fall. These findings suggest that the phonemic variations of tones reflected in context contribute to NNS’ difficulty in perceiving Mandarin lexical tone. In short, the above studies consistently illustrate that Mandarin tonal pitch variations, which are based upon dynamic phonological contexts, enhance learners’ difficulty in perceiving and producing Mandarin lexical tone.

As a whole, the above studies reveal how three linguistic factors affect Mandarin learners’ tonal perception and production. It is not difficult to see the complexities of how each phonetic cue of Mandarin tones plays an individual role in the form of isolation/citation, disyllable structures and syntactic structures. Concurrently, another four key sociolinguistic factors have also been found to contribute to learners’ learning difficulty in tonal perception and production. These factors are evaluated in the following sub-section.
1.4.3. **Four Sociolinguistic Factors**

Some studies have investigated the sociolinguistic factors that might contribute to learners’ learning difficulty in tonal perception and production. These factors were mainly learners’ LE in the form of bilingualism, age of L2 exposure, foreign language anxiety and gender impact (Horwitz, 1986; Holmes, 2001). Universally speaking, it is these factors which have been found to affect the language learning process and which may account for the different levels of performance in perceiving and producing Mandarin lexical tone by NNS. As the sociolinguistic factors such as age, anxiety and gender were not the focus in the current study, the following sub-sections will only briefly discuss age, anxiety and gender, but will specifically address the learners’ LE in the form of bilingualism, which will be one of the present research aims.

1.4.3.1. **Learners’ language experience in the form of bilingualism**

Learners’ language experience in the form of bilingualism could play a role in learners’ perception and production of Mandarin lexical tones. A number of studies (e.g. Bruck & Genesee, 1995; Bialystok, 1999; Bialystok et al., 2003; Marian et al., 2009; Ressel et al., 2012; Asaridou and McQueen, 2013; Krizman et al., 2014; Wang & Saffran, 2014; Yousaf & Khan, 2014) discovered that bilingualism in general gives learners an advantage in terms of the perception and production of a second or third language. Bilingualism has been shown to facilitate children’s and adults’ performance on meta-phonological tasks that probe the ability to analyze and manipulate language in terms of discrete phonemic units (Bruck & Genesee, 1995; Bialystok, 1999).
Specifically, Asaridou and McQueen (2013) suggest that linguistic experience, in particular learning in one language, modulates music processing and speech processing. Marian et al. (2009) indicates that a bilingual experience could provide linguistic perceptual benefits. L2 language ability has found to have a gradient effect on the target language. Krizman et al. (2014) investigated the effect of immigrant bilingualism on learning English as a foreign language. They discovered that speaking another language at home in addition to the instructional language at school provides an advantage in regard to learning English as a foreign language. Hence, an association between bilingualism and English foreign language achievement was revealed. Similarly, Wang and Saffran (2014) found that a bilingual experience enhanced learning outcomes when compared to the learning outcome of monolingual speakers, a finding which indicated a complex interplay between prior language experience and subsequent language learning. In addition, Yousaf and Khan (2014) investigated the role of bilingualism in terms of the learning behaviour of bilingual students in the setting of the multilingual society of Pakistan. The study results indicated that the ability of bilinguals to pragmatically understand different situations was relatively stronger than that of monolinguals.

Furthermore, Kaushanskaya and Marian (2009) indicated that bilingualism facilitates word-learning performance in adults. Word-learning performance was tested in monolingual English speakers, early English–Spanish bilinguals, and early English–Mandarin bilinguals. Novel words were phonologically unfamiliar to all participants, and they were acquired in association with their English translations. At testing, both bilingual groups outperformed the monolingual group. The findings suggest a general bilingual advantage for novel word learning. Moreover, Cenoz and Valencia (1994) examined the influence of bilingualism on third language learning in a bilingual
community, the Basque Country. The English-language achievement of students instructed through the majority (Spanish) and the minority (Basque) languages in the Basque Country was measured. The results indicated that bilingualism and several other variables (intelligence, motivation, age, and exposure) were good predictors of English-language achievement. Finally, there have also been reports on the linguistic auditory processing advantages originating from bilingualism (Krizman et al., 2012). Similarly, Ressel et al. (2012) examined the effect of the bilingualism on the auditory cortex, and found that learning an additional language is a causal factor in the increased size of the auditory cortex, which ultimately helped to enhance foreign/L2 (i.e. The second language)/L3 (i.e. The third language) language achievement. Overall, it is evident that learners’ LE such as bilingualism plays a role in learners’ perception and production of foreign/L2/L3 learning.

Above all, it is evident that the prior studies conducted research on either English as the subjects' second language or on their primary languages. In addition, they focused on full syntactic sentences rather than on words in the target languages. Concurrently, most of these studies focused on the perception of the target language instead of both perception and production. Furthermore, prior studies did not clarify how bilingualism should be defined. There are a range of definitions in the literature from the narrow to the broad (Romaine, 1995). At one end of the spectrum would be that of Bloomfield, which specifies ‘native-like’ control of two languages as the criterion or bilingualism (Bloomfield, 1933, P.56). In contrast, Haugen draws attention to the other end, when he observes that ‘bilingualism begins when the speaker of one language can produce complete meaningful utterances in the other language’ (Haugen, 1953, P.7). In more recent research, Mackey points out that the concept of bilingualism has become increasingly broader. He considers bilingualism as something entirely relative because
the point at which the speaker of a second language becomes bilingual is either arbitrary or impossible to determine. He therefore concludes that ‘bilingualism is simply the alternative use of two or more languages’ (Mackey, 1968, P.555). Given the varying definitions of bilingualism, it is possible that the bilingualism assumed in most of the prior studies tends toward a narrow interpretation, as the participants were early bilingual speakers who were able to speak additional language from childhood.

To fill these gaps, the current study will focus on the perception and production of Mandarin lexical tones of monosyllables and disyllables rather than phonological sentences. Furthermore, unlike the prior studies, the broad definition of bilingualism will be adopted in this study, as the learners in this study will be a mix of early bilingual speakers and late bilingual speakers, some of whom learned the additional language before and some after reaching puberty in different environment settings (See details in section 2.4.1). In short, few studies investigated whether learners’ LE in the form of bilingualism has positive effect or plays a role in perceiving and producing Mandarin lexical tones in monosyllable and disyllable structures by NNS of Chinese. For this reason, the present study will attempt to provide an answer for this neglected area, which will become another research aim (See research sub-question #4 in section 1.6).

1.4.3.2. Age of L2/foreign language exposure

Young children acquire an authentic accent in a foreign language far more easily than do adults, but this special facility is said to disappear about the time of puberty (Thogmartin, 1982; Johnson & Newport, 1989; 1991). It has been suggested that the age of L2/foreign language exposure and level of fluency are important determinants in L2/foreign language acquisition and processing (Wang et al., 2003). This helps to
explain why earlier Mandarin learners tend to learn the sound perception faster and more easily than do late Mandarin learners: because the language-specific framework for sound perception was being formed long before the infants were competent speakers of their native language (Kuhl et al., 1992).

1.4.3.3. Foreign language anxiety

Foreign language anxiety is less likely to prevent learners from performing as they normally would (Horwitz et al., 1986). It can be assumed that under particular circumstances such as an oral test situation, high anxiety might impair the language perception and production performance of Mandarin learners.

1.4.3.4. Gender impact

Sociolinguistics studies (Holmes, 2001; Burman, 2008) suggest that females learn a foreign or second language better than do males. According to Burman (2008), females showed significantly greater activation in language areas of the brain than males. This observation raises the possibility that females might tend to be more proficient in perceiving and producing Mandarin tones than males.

1.4.4. Overall discussion of section 1.4: Learning of Mandarin lexical tones

The preceding sub-sections have diagnosed three key linguistic and four key sociolinguistic factors contributing to the perception and production of Mandarin lexical tones. These diverse factors include the categorical nature of tone, the phonetic cues for tone, the context-dependent nature of tone sandhi, learners’ LE in the form of bilingualism, the learner’s age at L2 exposure and their foreign language anxiety, as well as gender impact. Among these seven factors, two factors, which are four important phonetic cues (i.e. pitch height, pitch contour, amplitude and duration) and learners’ LE in the form of bilingualism, were found to be underspecified in terms of
how these two factors precisely influence both the perception and production of Mandarin lexical tones by NNS of Chinese. These gaps (See sections 1.4.2.2.5 and 1.4.3.1) motivated me to carry out the current study and will therefore become two of the current research aims (See research sub-questions #3 and #4 in section 1.6).

On the other hand, apart from these seven factors contributing to learners’ tonal perception and production, NNS’ learning difficulty and problems seemed to remain unsolved. This indicates a need for further exploration of the factor(s) which may contribute to learners’ tonal perception and production. Intriguingly, both music and Mandarin Chinese are equipped with pitch height and pitch contour, but few studies have particularly investigated the potential link between learners’ musical aptitude and their Mandarin lexical tonal perception, as well as between musical aptitude and tonal production. In other words, little research has thus far been conducted on another potential factor affecting learners’ perception and production of Mandarin lexical tones: learners’ musical aptitude. Results from the small body of research in this area have been inconsistent: some investigators found little or no relationship between musical aptitude and second language learning of tone (e.g. Poeppel, 2001; Anvari et al., 2002), but other investigators found such a relationship to exist (e.g. Zatorre et al., 2002; Slev & Miyake, 2006; Wong et al., 2007). The use of different criteria, as well as the unreliability of inconsistent measures of audio-lingual skills, doubtless contributed to the diversity of these results. The inconsistency among the results of prior studies motivated me to develop the other three research aims (to be discussed below in section 1.5), in addition to the aforementioned two research aims including phonetic cues of Mandarin lexical tones and learners’ bilingualism. Hence, section 1.5 below will help to reveal the other three research aims of the current study.
1.5. Music and Language

Although Delogu et al. (2009) found evidence of the benefits of musical ability on non-musical activities such as spatial reasoning, mathematical abilities, mental imagery, symbolic reasoning, visuospatial abilities, and general intelligence, the nature of the relationship, between music processing and other cognitive domains such as language in general and Mandarin tones in particular still remains unclear. This part begins with a definition of musical aptitude and goes on to discuss the disagreements in the prior studies that investigated the relationship between music and language in general. This is followed by a review of studies which have found a specific link between music and tonal languages. Subsequently, the particular link between musical aptitude and Mandarin tones is discussed, followed by a review of the literature on the effect of musical training or ME in language perception and production. Furthermore, the prior studies regarding whether learners’ tonal learning experience/tonal training helped to enhance their tonal perception and production were reviewed. Finally, studies which did not support a link between music and language are examined. The other three research aims (See research sub-questions #1, #2 and #5 in section 1.6) will emerge by reviewing the prior studies in section 1.5.

1.5.1. Definition of the musical aptitude

The definition of musical aptitude has been debatable: some investigators claim that MA (i.e. having a fine ear for music) is the innate ability to learn or appreciate music, and especially to distinguish off-key and off-pitch music (Gordon, 1965). This view suggests that the ability to appreciate and to understand music does not require any musical training, and that people with musical talent have certain regions of the brain that are more developed than those of other people (Gordon, 1965; Patel, 2008). Others investigators suggest that experience, and not genetics, affects a musicians'
brain responses and development (Coon & Carey, 1989). In short, these divergent definitions suggest two interpretations of MA: one is that it is internal and innate, and the other that it is external and acquired through training/learning, only obtained by years of musical experience (ME). Due to the differences in how MA is defined, the researcher needs to explicitly clarify which interpretation of MA is to be investigated in their research context. In other words, the two opposing MA definitions aroused my interest to explore how MA should be defined in a rigorous manner, which assisted in formulating one of my research sub-questions. Doing so will assist in selecting an appropriate, valid and reliable MA test to serve the investigators’ research aims.

One immediate problem is that none of the previous studies precisely clarifies what is meant by MA; instead, vague terms such as musical ability, musicality, music intelligence, musical aptitude, and musical talent (e.g. Slevc & Miyake, 2006; Delogue et al., 2009; Cooper & Wang; 2010; Wang et. al., 2012) are used interchangeably. These cited studies appear to focus on learned or trained musical ability instead of the innate nature/genetics of musical aptitude, but they do not explicitly define that they were doing so. This lack of clarity implies a complex interplay between innate MA and learned/trained MA, which may lead to ambiguity about the concept of MA and accordingly an inappropriate selection of a MA test. For instance, several studies (e.g. Delogu et al., 2006) applied musical aptitude tests such as the Gordon PMMA (Primary Measures of Music Audiation) (1979), the Gordon IMMA (Intermediate Measures of Music Audiation) (1986), and Bentley’s The Measures of Musical Abilities (1966a) to their adult subjects. This is despite the fact that all of these tests had specifically been designed for either children or junior/senior high school students. In addition, other studies (e.g. Cooper & Wang, 2010), applied
musical aptitude tests such as Wing’s The Standardised Tests of Musical Intelligence (Wing, 1970) which requires their subjects, who had not received any musical training nor had a musical background, to display certain musical achievements. Furthermore, some studies (e.g. Delogu et al., 2009; Wang et al., 2012) applied the Seashore Measures of Musical Talent (Seashore, 1919; 1960) and Musical Aptitude Profile (Gordon, 1965) tests to professional musicians with significant levels of musical achievement despite both tests having been designed for maximizing the innate nature of one’s musical aptitude and minimizing one’s learned/trained musical achievement.

It is evident that the lack of clarity in regard to the definition of MA resulted in an inappropriate selection of MA tests, thus affecting the reliability and validity of the research undertakings. The inappropriate use of MA tests in previous studies may partially explain the inconsistent research findings in relation to the association between learners’ MA and their tonal perception, as well as their tonal production. To resolve these issues, the current study will attempt to provide a precise, explicit and robust definition of musical aptitude. The precise definition of MA will be derived from the research results and discussions (See section 3.2.2 in Results Chapter and section 4.3.2.3 in Discussion Chapter), and will therefore become another research aim of the current study (See research sub-question #1 in section 1.6). Providing an explicit definition to MA not only contributes to the selection of an appropriate MA test (to be introduced in detail in section 2.4.2.2 in the Methodology Chapter), but also serves to evaluate the effect of MA in the target language. The following sub-section will examine the studies which explored the relationship between music and language in general.
1.5.2. The close link between music and language

Behavioural and neuro-scientific studies have indicated that speech and music share mechanisms for sound category learning, that is, music and language share several cortical and sub-cortical areas, even though the two domains build their primary sound categories from different features of sound. On the surface, the two domains are dramatically different. Music uses pitch in ways that speech does not, and speech organizes timbre to a degree seldom seen in music. Yet beneath these differences lie deep connections in terms of cognitive and neural processing (e.g. Zatorre et al., 2002; Slev & Miyake, 2006; Wong et al., 2007). Psychophysiological evidence supports a music-language association, such that experience in one domain can impact the processing required in the other domain (Hutka et al., 2015). Music proficiency is a good predictor for language acquisition skills, both in L1 and in L2 contexts (e.g. Zatorre et al., 2002; Slev & Miyake, 2006; Wong et al., 2007; Jäncke, 2009; Asaridou & McQueen, 2013; Hutka et al., 2015). For this reason, Hutka et al. (2013) advocated a shift from a linear model to a non-linear model, namely BSV, in order to further investigate the complex relationship between music and language. Their findings further support the perception that music and language share similar networks in the brain and have similar but not identical functions.

At the behavioural level, musical aptitude correlates uniquely with L2 phonological production and perception abilities in adults (Slevc & Miyake, 2006), as well as in children (Milovanov & Tervaniemi, 2011). This correlation between the ability to perceive, discriminate and process musical sounds, on the one hand, and the ability in musically naïve individuals to perceive and pronounce non-native speech sounds on the other, suggests that common processing mechanisms mediate both musical sounds and non-native speech sounds. Bidelman et al. (2010) demonstrated that pitch
experience in either music or language can transfer from one domain to the other. Milovanov and Tervaniemi (2011) revealed an intriguing interplay between musical aptitude and L2 linguistic abilities: the higher the musical aptitude, the better were the L2 pronunciation skills. Brutten et al. (1985) showed that ESL students’ musical abilities account for variance in attained ESL oral proficiency. Chandrasekaran et al. (2009) found that both music and language experience modulate the automatic early cortical processing of dynamic, non-speech pitch trajectories, which implies that a link exists between music and language.

In addition, Liu et al. (2015) indicated that congenital amusia is a neurodevelopmental disorder of musical processing that also impacts speech processing. Similarly, Burnham et al. (2015) explored the relationship between the processing of speech and music via the linguistic vehicle of lexical tone, and found people with amusia to be impaired in linguistic tasks such as identifying tonal categories. Moreover, people with amusia who speak non-tonal languages have difficulty processing different musical tones, melodic contours, and songs (e.g. Ayotte et al., 2002; Peretz et al., 2003; Foxton et al., 2004; Hyde & Peretz, 2004; Gosselin et al., 2009).

Furthermore, previous work has focused on the effects of either musical expertise (non-native musicians vs. non-musicians) or linguistic expertise (native vs. non-native speakers). To fill the gap, Chandrasekaran et al. (2009) directly compared the two domains of expertise (non-native musicians vs. native Chinese speakers) to determine whether processing of pitch contours, as reflected by mismatch negativity (MMN)\(^3\) is specific to the domain of experience (language vs. music). The results reflect that both

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\(^3\) MMN: a useful tool for studying the structure of sound categories, and an excellent tool for investigating automatic processing of supra-segmental information in speech. Using a passive oddball paradigm, the MMN has been shown to be influenced by differences in the relative saliency of pitch dimensions across languages (Patel, 2008).
music and language experience modulate automatic early cortical processing of
dynamic non-speech pitch trajectories. In other words, experience-dependent
plasticity at early pre-attentive stages of processing is not specific to speech or the
domain of experience, but is sensitive to the context of the learning experience (music
vs. language), which consistently implies the existence of a link between music and
language.

Overall, the above research reveals the close interplay between music and language.
The following sub-section more specifically reviews studies on the link between
music and tonal languages.

1.5.3. Music and tonal languages

In addition to the above studies on music (aptitude) and language in general, other
studies (e.g. Deutsch et al. 2004, 2006; Ward 1999) have specifically discovered a
link between music and tonal languages. For example, Hutka et al. (2015) discovered
that musicians and Cantonese speakers performed comparably in pitch discrimination;
but musicians showed better timbre discrimination performance and enhanced MMN
responses to both music and speech. These results suggest that while both
musicianship and tone language experience enhance some aspects of auditory acuity
(behavioural pitch discrimination), musicianship confers farther-reaching
enhancements to auditory functioning, tuning both pitch and timbre-related brain
processes (Hutka et al., 2015).

In addition, Cooper and Wang (2010) utilised AMMA (i.e. Advanced Measures of
Music Audiation) (Gordon, 1989) which were specifically designed for high-school
students and found that the level of overall attainment in Cantonese tone word
learning for English speakers can in part be predicted by their level of musical
aptitude. Similarly, Delogu et al. (2010) suggested that musical aptitude can also predict performance in linguistic tone discrimination in non-tone-language speakers. Non-tone-language speakers who score highly in melodic perception tasks also score highly in tonal discrimination tasks (Delogu et al., 2010). Deutsch et al. (2004; 2006), and Lee et al. (2008; 2009, 2010) found that speakers of two tone languages—Vietnamese and Mandarin—exhibited a remarkably precise and stable form of absolute pitch\(^4\) in reciting lists of words. Given these findings, it was conjectured that absolute pitch evolved as a feature of speech, analogous to other features such as vowel quality. It was further conjectured that tonal language speakers acquire this feature in infancy, during the critical period in which infants acquire other features of their native language (Kuhl et al., 1992; Doupe and Kuhl, 1999) and so can later acquire absolute pitch for music in the same way they acquire the features of a second tonal language. Hence, the prevalence of absolute pitch among tone language speakers tends to be higher overall than for speakers of intonation languages (Deutsch et al., 2004). Tonal language speakers’ existing linguistic experience seems to have had an obvious advantage on their performance in learning another tonal language (e.g. Ward 1999; Deutsch et al., 2004; 2006; Xie & Myers, 2015). Likewise, Cooper and Wang (2012) suggest that when compared to those without tone language experience, a tone language background leads to significantly better non-native word learning proficiency. Although it has been suggested that the increased prevalence of absolute pitch among certain Asian populations reflects genetic factors (Zatorre, 2002), it may also be related to their experience of speaking a tonal language. Bidelman et al. (2010) compared adult Cantonese-speaking non-musicians, English-

\(^4\) Absolute pitch is generally considered to reflect a rare musical endowment. It is the ability to identify the frequency or musical name of a specific tone or, conversely, the ability to produce some designated frequency, frequency level, or musical pitch without comparing the tone with any objective reference tone (Ward, 1999; Deutsch et al., 2004, 2006).
speaking non-musicians and English speaking trained musicians on music-processing tasks (e.g., pitch discrimination and memory). They found that Cantonese speakers’ performance was comparable to that of musicians and was enhanced relative to the English speaking non-musicians. This finding suggests the presence of absolute pitch tends to enhance tonal language speakers’ performance in music-processing tasks. Interestingly, recent studies have found that musical aptitude scores are significantly correlated with word learning success for English, but not for Thai listeners who are tonal language speakers (Cooper and Wang, 2010). It is not difficult to see that absolute pitch for music and tonal languages share common brain mechanisms.

Furthermore, a survey (Wee, 2008) of Mandarin songs indicates that linguistic tones are often not faithfully preserved in tune, consequently giving rise to the question of how listeners are able to decipher words that are sung. Wee (2008) argues that it depends on two elements: headship in music and headship in linguistic tones. A head in music or language is a special position where the features of the residing element are prominent. The fact that one mode has to take precedence over the other suggests that they share some attributes, but it does not mean that they share all of them.

Finally, Brutten et al. (1985) carried out an empirical validity study to determine the extent to which musical abilities (pitch, loudness, and rhythm) could be measured by the Seashore Measure of Musical Talents test, and verbal memory measured by a sentence repetition task. The results showed that L2 learners’ musical abilities account for variance in attained English oral proficiency. Overall, the aforementioned studies consistently reveal a close link between music and tonal languages. By reviewing the limited number of prior studies on this topic, the following sub-section specifies the link between MA and learners’ Mandarin tone learning.
1.5.4. Musical aptitude and Mandarin tones

Using Wing’s musical test (1962), Delogu et al. (2006) found that melodic ability could improve learning of Mandarin tones by native non-tonal speakers. Delogu et al. (2009) additionally found that musical ability could enhance Mandarin Chinese lexical tone discrimination: musicians used their fine melodic contour competencies to solve linguistic perceptual problems, and this music effect seems also to be effective in non-musicians with high melodic competencies. It seems to be that a positive transfer effect can make up for the lack of linguistic competence by allowing musicians to use music-like processing in tonal discrimination.

Delogue et al. (2009) subsequently showed that both melodic proficiency and music expertise are good predictors of better tonal, but not phonological identification. In order to investigate the correlation between music and Mandarin Chinese lexical tone perception, Wang et al. (2012) assessed the music perception ability of Chinese adult cochlear implant users. Lexical tone perception was found to be significantly correlated with music pitch perception, supporting the notion that tone and music perception may share a similar pitch perception mechanism. Previous research has shown that people with amusia who speak non-tonal languages have difficulty processing different musical tones, melodic contours, and songs. (e.g. Ayotte et al., 2002; Peretz & Coltheart, 2003; Foxton et al., 2004; Hyde & Peretz, 2004; Gosselin et al., 2009). Similarly, early exposure to a tonal language may compensate for pitch disorder (Peretz, 2008).

Jiang et al. (2010) further discovered that individuals with amusia were impaired when trying to discriminate and identify melodic contour, and that this deficit extended to speech processing, especially in a tonal language such as Mandarin.
Chinese. Chinese post-lingually deafened cochlear implant users performed significantly worse in pitch discrimination and timbre perception tasks than normal-hearing listeners (Wang et al., 2012). In other words, impairment in musical processing also affects speech processing of a tonal language, such as Mandarin Chinese. Impairment in musical processing thus also affects speech processing of Mandarin Chinese, which seems to indicate a close link between music and Mandarin lexical tonal perception, as well as tonal production. The following sub-section highlights the effect of musical training/experience on learners’ tonal perception and production.

1.5.5. Musical experience/training on language learning

A number of studies have highlighted how musical training/experience enhances speech processing (e.g. Jäncke, 2009; Asaridou & McQueen, 2013; Chorbert et al., 2012; Kang & Williamson, 2014; Patel, 2014). Specifically, when music and speech share sensory or cognitive processing mechanisms in the brain (music places higher demands on these mechanisms than does speech), the stage is set for musical training to enhance speech processing (Patel, 2014). The overlapping of neuro-cognitive systems leads to the possibility that training in one domain may enhance processing in the other (Patel, 2008). Burnham et al. (2015) discovered a relationship between the processing of speech and music via the linguistic vehicle of lexical tone. All musicians showed greater accuracy, faster reaction times and less variation in accuracy across stimulus types than non-musicians. Asaridou & McQueen (2013) showed that the musical experience of trained musicians modulates speech processing, particularly in the case of pitch processing. Individuals with music training are better at discriminating and imitating Mandarin tones than non-musicians, even when the task requires categorical rather than pure auditory perception (Gottfried et al., 2004).
Jäncke (2009) illustrated that musical practice is associated with the structural and functional plasticity of the brain. Musical elements could be used to improve specific cognitive functions for which positive transfer effects have been demonstrated. The author used examples of reading, speaking, writing and listening skills which could benefit from musical training. Similarly, Chobert et al. (2012) demonstrated that musical training positively influences linguistic abilities. Kraus and Chandrasekarn (2010) found that musical training leads to changes throughout the auditory system that facilitates language perception and production.

Furthermore, Kang and Williamson (2014) found that musical experience is a relevant factor in being able to predict enhanced performance in certain language tasks. Besson et al. (2007) found that musically trained adults were better at detecting pitch contour variations in music and language stimuli than non-musically trained adults. Marques et al. (2007) reported a similar group difference when examining the ability to detect pitch variations in foreign languages. This pattern has been found in children (Magne et al., 2006) and in adult event-related potentials (ERP) studies of language learning (François & Schöhn, 2011). Ultimately, musical training has been found to have a positive effect on pronunciation of L2 languages (Milovanov et al., 2009; 2010). Hence, musical training and experience may boost language learning skills and that this effect might be most clearly seen in a tone language, where accurate perception and production of pitch contours is crucial to comprehension.

Cooper and Wang (2012) examined how linguistic and musical factors influence the non-native word identification and lexical tone perception of Cantonese words. The findings suggest that either musical experience or a tone language background leads to significantly better non-native word learning proficiency, when compared to those with neither musical training nor tone language experience. Musicianship was found
to be more advantageous than a tone language background for tone identification. Numerous studies have found that musicianship assists non-tone language participants to identify and discriminate between non-native lexical tones (Alexander et al., 2005; Lee & Huang, 2008; Delogu et al., 2006; 2009). Delogu et al. (2009), for example, found that musical expertise predicted better non-native tone identification in Italian adults and children. Similarly, English musicians displayed significantly better accuracy rates than non-musicians when identifying Mandarin lexical tones on intact, silent-center and onset-only syllables ((Lee & Huang, 2008).

Finally, there is also some evidence pointing to neurophysiological changes as a result of long-term exposure to musical pitch and its effect on linguistic pitch processing (Wong et al., 2007). Wong et al. (2007) reported that English musicians have more robust encoding of linguistic pitch in the auditory brainstem when listening to Mandarin lexical tones, suggesting that long-term pitch exposure may alter fundamental sensory circuitry. The effect of musicianship was also found in tone word learning. Wong and Perrachione (2007) reported that musicians were more successful than non-musicians at learning to use pitch for lexical identification. Neuroplasticity in the child brain suggests that active musical training rather than an innate predisposition for music were responsible for yielding an improvement in lexical identification in musically trained children (Chobert et al., 2012). Kraus and Chandrasekaran (2010) claimed that children can improve their linguistic listening skills through music training.

It is evident therefore that the studies cited above provide robust evidence that musical experience enhances auditory acuity, which can aid in speech acquisition in general, and tonal perception and production in particular.
1.5.6. Discussion of sections 1.5.2, 1.5.3, 1.5.4 and 1.5.5

Altogether, sections 1.5.2, 1.5.3, 1.5.4 and 1.5.5 jointly support the claim that music and language in general, more specifically music and tonal languages, and musical aptitude and Mandarin tones, as well as musical experience/training and the language learning, have a close link. However, most of the previous studies were neuro-scientific and psychophysiological, and focused on trained/learned MA (i.e. ME) rather than on both innate MA/talent/genetics and trained/learned MA (i.e. ME). No research has yet applied a MA test corresponding to the primary acoustic cues of Mandarin lexical tone, including pitch height, pitch contour, loudness and duration. In addition, other variables in the previous studies were not well controlled. These include the specific language being investigated (e.g. most previous studies focused on L1 and L2 in general, and Cantonese tone in specific.), and the aspects of MA and language skills being investigated (e.g. most of the studies focused on only partial aspects of MA such as melody or timbre). Most of the studies also compared NS of Mandarin Chinese to English speakers; no study has been carried out that clearly differentiates NNS learners from an unrelated tonal language (e.g. Thai and Vietnamese rather than Mandarin-Chinese) and non-tonal language speakers (e.g. English) in regard to their Mandarin lexical tone learning. In short, previous studies, investigating the relationship between learners’ MA and their Mandarin lexical tonal perception, as well as tonal production, in particular, are scarce. At the same time, none of the previous studies have clarified the precise strength (i.e. small/weak, medium/moderate, large/strong) of the relationship between music (aptitude) and

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5 The current study intended to compare and contrast tonal language speakers (e.g. Vietnamese) with non-tonal language speakers (e.g. English, Korean), but unfortunately the sample size of tonal language speakers was extremely small. For this reason, this research aim was unable to be achieved, and was accordingly eliminated in this study.
language in general, or between MA and Mandarin learners’ lexical tonal perception, as well as tonal production, in particular.

In these regards, in order to provide more conclusive evidence, the current study provides a more rigorous and precise research design than previous studies by considering the aforementioned aspects neglected by prior studies. An additional feature of the current study that distinguishes it from previous studies is that it seeks to determine the specific strength of any correlation between Mandarin learners’ MA and their tonal perception, as well as between MA and their tonal production. In other words, the current study vigorously investigates the effect of MA, on Mandarin tonal perception and production by NNS of Chinese. Ultimately, the current study will on the one hand attempt to discover whether the MA of NNS helps in their tonal perception and production at the early stage of their learning, by evaluating the relationship between learners’ musical aptitude and learners’ tonal perception, as well as tonal production. This will become another research aim of the current study (See research sub-question #2 in section 1.6). On the other hand, at the later stage of learners’ learning, the current study aims to evaluate whether any potential effect of MA in learners’ tonal perception and production changes over time. This dynamic dimension of MA was not discovered in previous research, and will hence become the final research aim of the current study. To achieve this research aim, the prior studies that highlight the importance of learners’ tonal learning experience/tonal training in their tonal perception and production need to be evaluated as follows.

1.5.7. Tonal learning experience/Tonal training

Leather (1987) examined the effect of production training on perception in a group of Dutch speakers. The participants were trained to produce four Mandarin words
differing in tone. He found that the Dutch speakers were able to perceive the differences in tone after their production training. The author also observed the effect of perceptual training on production and concluded that training in one modality tended to be sufficient to improve the learners’ performance in the other. Other studies have also consistently shown that after short perceptual tone training, non-native speakers of Mandarin improved both their perception and production of Mandarin tone (Leather, 1987; Wang et al., 2001a; 2003). In addition, Cooper and Wang (2012) similarly indicated that sustained linguistic pitch experience influences the pitch processing mechanisms which aid in the acquisition of tone words. Wang et al. (2003) undertook longitudinal case studies to examine the roles of language experience and the input of tonal training (both communicative and instructional conditions) in the production and perception of Mandarin tones and speech prosody. It was found that tonal training significantly improved learners’ perception and production of Mandarin tones and speech prosody.

So (2005) compared Japanese speakers’ Mandarin tonal performance in a pretest with their performance in a posttest, and discovered that Japanese listeners were less confused in a posttest by contrastive tone pairs after the tonal training. This finding implies that tonal training or learning experience does enhance learners’ perception and production of Mandarin tones. Wayland et al. (2010) suggest that perceptual tonal training facilitates a speaker’s normalization process in lexical tone perception, such as Thai lexical tones. These results suggest overall that tonal learning experience, specifically tonal training, produces highly generalized learning that results in long-term modifications to the learners’ perception and production of Mandarin tones. The long-term modifications to the learners’ perception and production of Mandarin tones may enable learners to associate meaning to lexical tones rather than to listen to
lexical tones as pitch differences (Wang, 2003). This transformation would make later stage learning more meaningful than learning at the early stage, a transformation which may ultimately contribute to learners’ enhanced tonal perception and production.

Above all, it is notable that tonal training that focuses on both form and meaning produces the best learning outcome for learners. It is also evident that most of the prior studies focused on the effect of tonal training in learners’ tonal performance only, but none of the above studies carried out a longitudinal study to particularly investigate how learners’ tonal training affects the potential effect of MA in their tonal perception and production. Hence, the present study will investigate whether the potential effect of learners’ MA in their tonal perception and tonal production changes as their tonal training in the formal classroom setting increases. This will be the final research aim in the current study, which will correspond to research sub-question #5 (See section 1.6). Doing this further assists in discovering over an extended period of tonal training time whether learners’ potential MA still helps in their tonal perception and production.

In sum, all the of studies reviewed above are in agreement that music and language in general, music and tonal languages, as well as musical aptitude and Mandarin Chinese in specific, have a close link. Concurrently, musical experience/training and tonal learning experience/tonal training were discovered to enhance learners’ language performance. However, as discussed immediately below, there are also studies which do not support a close link between music and language, and this lack of consistent controls across the papers accounts for the context-dependent findings which led to the inconsistent conclusions. These inconsistent conclusions will aid in exploring the final research aim (See research sub-question #5 in section 1.6) in the current study.
1.5.8. No/little link between music and language

Although the aforementioned studies indicated a connection between music and language in general, more specifically between music and tonal languages, and between musical aptitude and Mandarin tones in particular, as well as between ME and Mandarin tonal perception and production, the following studies did not clearly support a link between music and language.

First, Patel (2008) showed that the brain treats spoken and musical sound systems differently: focal cortical damage can lead to dramatic dissociations whereby the ability to interpret speech is profoundly impaired, yet the perception of musical sounds remains intact, or vice versa (Peoppel, 2001; Peretz & Coltheart, 2003). In other words, sound category representations in the two domains, once learned, do not completely overlap in terms of their location in the brain.

Second, previous studies have analysed the complex brain laterализation of tone processing between music and language. Although the right hemisphere is argued to be dominant in the processing of musical pitch, intonational prosody, and other non-lexical pitch-related perceptual abilities, the left hemisphere appears to be dominant in intonation, which assumes a lexical contrastive function, (Van Lancker & Fromkin, 1973). Strong evidence for the linguistic role of pitch processing in tonal languages has been derived from neuropsychological studies (Gandour et al., 1992), neuroimaging (Klein et al., 2001), and electrophysiology (Brown-Schmidt & Canseco-Gonzalez, 2004). Based on this evidence, Delogu et al. (2009) concluded that pitch processing in lexical tone perception is, at least to some extent, a domain-specific linguistic function, which seems to emphasize the leftward bias of pitch perception rather than a bilateralized processing of pitch representation previously
proposed by Hickok and Poeppel (2004). Similarly, it is well known that tasks that focus participants’ attention on phoneme perception are associated with greater left-hemisphere activity in neuroimaging studies, often involving a network that spans the left superior temporal auditory temporal cortex and the left inferior frontal cortex (Zatorre & Gandour, 2008). In contrast, many tasks involving musical pitch perception show a right hemisphere bias. Zatorre et al. (2002) and Poeppel (2001; 2008) suggest that the hemisphere difference between speech and music is due to complementary anatomical and functional specializations of the two auditory cortices for processing the temporal versus spectral structure of sound. According to this view, Patel (2008) indicated that perception of the rapid but spectrally coarse timbral contrasts of speech relies on left hemisphere circuits, whereas analysis of slower but more spectrally refined pitch contrasts of music relies on right hemisphere circuits.

The dissociations and discrimination revealed in the above studies do not clearly support a link between music and language. However, it is worth noting that none of the above studies carried out a longitudinal study to investigate the relationship between music and language. In other words, none of above studies examined when the potential effect of MA in language occurs and diminishes. Hence, by conducting a longitudinal study, the current research will examine whether any potential effect of MA in Mandarin tonal perception and production changes over time. This will assist in investigating the final research aim of the current study (See research sub-question #5 in section 1.6).

1.5.9. Overall discussion of the literature on music and language

The prior studies reviewed above have made theoretical contributions to the relationship between music and language in general, more specifically between music
and tonal languages, MA and Mandarin tones in particular, as well as between musical experience and language learning, but their findings have been inconsistent. Additionally, how tonal learning experience/tonal training enhances learners’ tonal perception and production was explored in prior research. However, three major issues which were not adequately investigated have emerged here. The three issues are the precise definition of musical aptitude (See section 1.5.1), the relationship between learners’ musical aptitude and learners’ tonal perception, as well as tonal production (See section 1.5.6), and whether the potential effect of MA in the perception and production of Mandarin lexical tones changes over time (See sections 1.5.7 and 1.5.8). These three issues will therefore be investigated and resolved in the current research, together with the aforementioned two issues (i.e. the phonetic cues of Mandarin lexical tones, learners’ LE in the form bilingualism) identified in section 1.4 above.

1.6. Summary of the chapter and the aims of the current research

By providing a background of the role of Mandarin Chinese and Mandarin lexical tones in Chinese language, this chapter reviews the prior studies in two parts. Section 1.4 reviews the studies on the learning of Mandarin lexical tones and section 1.5 reviews the studies on the relationship between music and language. Initially, in order to improve NNS’ learning, earlier research explored the source of difficulty for NNS in learning Mandarin lexical tone. The sources of difficulty can be categorized into three linguistic factors and four socio-linguistic factors. The former linguistic factors include the categorical nature of tone, the phonetic cues for tone, and the context-dependent nature of tone sandhi; the latter sociolinguistic factors include the learners’ language experience in the form of bilingualism, the learner’s age, foreign language anxiety and the impact of gender (Chao, 1968; Brown, 1980; Hassler et al., 1985; Xu,
Among the seven factors, the phonetic cues of Mandarin lexical tones and learners’ LE in the form of bilingualism seemed underspecified in prior studies, and hence will become two of the current research aims.

On the other hand, although these seven factors have been found to contribute to the perception and production of Mandarin lexical tone, learners’ learning difficulty and the problem of Mandarin lexical tones remain unresolved. Another potential intriguing factor affecting learners’ perception and production of Mandarin lexical tones--learners’ MA, motivates the current study. However, results from this small body of research have been inconsistent: some investigators found little or no relationship between musical aptitude and L2 learning of tone (e.g. Peoppel, 2001; Anvari et al., 2002), while other investigators have found such a relationship to exist (e.g. Zatorre et al., 2002; Slev & Miyake, 2006; Wong et al., 2007). No studies have particularly investigated the tentative link between learners’ MA and their Mandarin lexical tonal perception, as well as tonal production. By reviewing the prior studies in section 1.5, three major neglected issues emerge: the precise definition of musical aptitude, the relationship between learners’ musical aptitude and learners’ tonal perception, as well as tonal production, and whether the potential effect of MA in their tonal perception and production changes as learners’ tonal learning experience increases over time. Specifically, previous studies investigating the relationship between learners’ MA and their Mandarin lexical tonal perception, as well as tonal production, are scarce. Additionally, none of the previous studies have clarified the definition of MA and provided the precise strength (i.e. small/weak, medium/moderate, large/strong) of the relationship between music (aptitude) and language in general, or between MA and Mandarin learners’ lexical tonal perception,
as well as their tonal production. It is also the case that none of the studies carried out a longitudinal study to investigate the association between MA and tonal perception or tonal production over time. These limitations are less likely to guarantee a statistically reliable and valid finding.

In these regards, in order to provide more conclusive evidence, the current study will attempt to provide a more rigorous and precise research design than previous studies by considering the aforementioned neglected issues noted in sections 1.4 and 1.5. It will also attempt to measure more specifically the strength of any correlation between Mandarin learners’ MA and their tonal perception, as well as between MA and their tonal production. This will involve two stages of testing (i.e. a longitudinal study): an early stage testing and a later stage testing. By utilizing a questionnaire, an innate MA test, a Mandarin lexical tone listening test (for perception), and a Mandarin lexical tone speaking test (for production), this study will provide an initial, precise, robust definition of MA. Secondly, the study will evaluate if there is a significant correlation between learners’ MA (to be defined) and their tonal perception, as well as tonal production, which is followed by an exploration of what aspect of MA provides the most advantage in NNS’ tonal perception and tonal production respectively. Subsequently, the study will examine in addition to MA, what other factor(s) play(s) a role in NNS’ Mandarin tonal perception and production. Finally, if MA is a factor in Mandarin tone perception and production at the early stage of learners’ earning, the study attempts to discover whether its impact changes over time. The main research question and sub-questions of the current study are formulated in the following sequence, where the first four sub-questions will be investigated during the early stage testing, and the final sub-question will be explored during the later stage testing.
Main research question:
Does musical aptitude help non-native speakers of Chinese in their perception and production of Mandarin lexical tones at different stages of their learning?

Research sub-questions:
Research Question (RQ) #1: How should musical aptitude (MA) be defined?
RQ #2: Is there a significant correlation between non-native speakers (NNS)’ MA and their perception and production of Mandarin tones?
RQ #3: What aspect of MA provides the most advantage in NNS’ tonal perception and tonal production respectively?
RQ #4: Are there other factor(s) in addition to MA that play(s) a role in NNS’ Mandarin tonal perception and production?
RQ #5: If MA is a factor in Mandarin tone perception and production, does it impact change over time?

In order to provide adequate responses to the above research questions, the next chapter, the Methodology Chapter, will illustrate the research design of the current study, the pilot study, participants, research instruments, research settings, data collection and the analysis procedure followed.

1.7. Structure of the thesis
The remaining structure of the thesis is as follows. Chapter Two presents the methodological approach to the study and the pilot study is briefly summarized. Subsequently, the processes for collecting and analysing data for the main study are explained. Chapter Three details the results obtained from the early stage testing and from the later stage testing respectively. Chapter Four, the Discussion, interprets these
results and goes on to compare them with the findings from previous research and evaluates their contribution to the expressed aims of the study and to the wider field. Chapter Five concludes the thesis by summarizing the key research findings, discussing the theoretical contributions of its findings, the implications for the learning and teaching practice of Mandarin lexical tones and their wider contribution to the learning and teaching of tonal languages, as well as identifying the limitations of the study and providing suggestions for future research.
Chapter 2: Methodology

2.1. Overview of the chapter

This chapter starts by outlining the purpose of the primarily quantitative study with qualitative elements. This is followed by a brief description of the purpose of the pilot study, and the manner in which the outcomes of the pilot study informed the research questions. The chapter then goes on to introduce the research design of the main study by dealing with the research instruments, participants, test setting, the collection procedure and recording of data and data analysis. The chapter ends with a summary of the outcomes of the pilot study and of the principal elements in the design of the main study.

2.2. Purpose of the study

The purpose of the overall study is as follows:

Main research question:
Does musical aptitude help non-native speakers of Chinese in their perception and production of Mandarin lexical tones at different stages of their learning?

Research sub-questions:
RQ #1: How should musical aptitude (MA) be defined?
RQ #2: Is there a significant correlation between non-native speakers (NNS)’ MA and their perception and production of Mandarin tones?
RQ #3: What aspect(s) of MA provides the most advantage in NNS’ tonal perception and tonal production respectively?
RQ #4: Are there other factor(s) in addition to MA that play(s) a role in NNS’ Mandarin tonal perception and production?

RQ #5: If MA is a factor in Mandarin tone perception and production, does its impact change over time?

The research project will be divided into two stages of testing: early stage testing and later stage testing. RQs #1, #2, #3 and #4 are to be explored during the early stage testing, and RQ #5 will be investigated during the later stage testing. The five sub-questions jointly respond to the main research question. Data will be gathered using a questionnaire, an innate MA composite test, a Mandarin lexical tone listening test (for perception) (MLT), and a Mandarin lexical tone speaking test (for production) (MST). The data gathered by the four research instruments will be analysed by the following four statistical methods: SPSS Spearman bivariate correlation, Spearman nominal correlation, Independent T-tests, and Paired T-tests (Field, 2009; Pallant, 2010). In discussing the results of the correlation analyses, Cohen’s guidelines (1988, P.79) of the correlation effect sizes (ESs), which is a general rule of thumb for the behavioural sciences (Durlak, 2009), will be followed in this study. The specific data analysis is described in detail in section 2.4.5.

The innate MA test is to be used to statistically assess learners’ innate MA, whereas, the questionnaire will be used to qualitatively discover learners’ different levels of ME. During the early stage testing, using bivariate correlation analysis, the study will investigate whether innate MA has a significant correlation with learners’ tonal perception and production; by nominally correlating different levels of ME with learners’ innate MA scores, MLT and MST, the study will examine whether ME has a significant correlation with learners’ innate MA, tonal perception and production. The
results from the above two types of correlation analysis will not be only used to define MA raised by RQ #1, but also answered RQ #2 whether there is a significant correlation between learners’ MA and their tonal perception, as well as between MA and their tonal production. In addition, different subtests of the innate MA composite test will also be used to correlate with MLT and MST, so that the RQ #3 regarding which aspect of MA provides the most advantage in learners’ tonal perception and production respectively will be further explored. Furthermore, the questionnaire will also help to indicate the participant’s language experience (LE) such as primary language spoken, or being bilingual or monolingual. This qualitative data will be utilized to compare and contrast bilingual speakers with monolingual speakers in terms of their performances on the innate MA test, MLT and MST. Doing this will help to explore the answer to RQ #4 in regard to what other factors in addition to MA play(s) a role in learners’ tonal perception and production.

Finally, during the later stage testing, the innate MA test, MLT and MST will be assessed once again. By bivariate-correlating the innate MA test scores with the MLT and MST, and comparing and contrasting learners’ performances on the innate MA test, and MLT and MST between both stages of testing, the longitudinal study will reveal whether learners’ tonal perception and production improve and whether the potential MA effect changes as their tonal learning experience/tonal training increases. This corresponds to the last RQ #5. Before launching on the research design of the main study, the following section provides a summary the pilot study the results of which aided in consolidating the design of the main study.
2.3. Pilot Study

In order to prepare for the main study investigating the formulated main research question and five sub-questions, a pilot study was undertaken. The first purpose of the pilot study was to determine whether the potential research instruments would provide a suitable basis for the proposed main study of the effect of MA on learners’ tonal perception and production, so as to assure the validity and reliability of the planned research instruments. The second purpose was to identify which aspects of the research questions and instruments should be excluded from, or modified for, the main study. The final purpose of the pilot was to discover which aspects of the research questions and instruments might usefully be included in the main study. As a result of the pilot study, the following modifications were made, which provided a solid foundation for the research design of the main study.

(1) An addition was made to the multiple-choice Questionnaire, this was, *I don’t enjoy listening to music and never participated in musical activities*. This addition led to the inclusion of all the cases/situations that the potential participants in the main study might have experienced.

(2) Recording instructions were added to the Seashore MA subtests, which assisted in smoothing the research testing procedure.

(3) Four additional tonal items were added to the MLT and MST which now had a total of 54 tonal items to be used in the main study. The four tonal items were items with lexical neutral tones, the aim being to include and maximize all the cases of lexical tones in disyllables.

(4) By qualitatively identifying different levels of learners’ musical experience, the main study will expand the sample size to investigate the effect of both innate MA
and learned/trained MA on learners’ tonal perception and production.

(4) Due to the extremely small sample size of TLS statistical analysis of the effect of
tonal language speakers and non-tonal language speakers on their tonal perception
and production was not conducted.

2.4. The Main Study

The main study was conducted during the course of the University of Auckland (UoA)
Chinese Stage I language course (i.e. Chinese 100) over the period March~ July 2012.
Data was gathered using a questionnaire, an innate MA composite test, a Mandarin
lexical tone listening test (for perception), and a Mandarin lexical tone speaking test
(for production). The collected data was correlated to establish the extent to which
MA effects learners’ Mandarin lexical tonal perception and production. The
methodological approach of the main study remains quantitative, but with qualitative
elements. I will now describe my research design in terms of participants, instruments
and data collection procedures, as well as the data analysis.

2.4.1. Participants

Table 2.1 Language Backgrounds of the 45 Participants

<table>
<thead>
<tr>
<th>Primary Language</th>
<th>No.</th>
<th>Other Language(s)</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>23</td>
<td>English</td>
<td>21</td>
</tr>
<tr>
<td>Korean</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vietnamese⁶</td>
<td>2</td>
<td>Japanese</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spanish</td>
<td>1</td>
</tr>
</tbody>
</table>

⁶ Vietnamese is a tonal language. Prior studies have indicated that tonal language speakers’ existing
linguistic experience seems to provide an obvious advantage in regard to their performance in another
tonal language (e.g. Deutsch et al., 2004, 2006; Ward, 1999). Hence, the original intention of the
current study was to investigate whether or not tonal language speakers perform differently from non-
tonal language speakers do in Mandarin tonal perception and production. Unfortunately, the extremely
small sample size of two tonal language speakers made this option impossible. However, future
research might expand the TLS sample size to provide a statistically significant research outcome.
Forty-five NNS of Chinese enrolled in the Chinese stage I course at the UoA were recruited. As Table 2.1 shows, the participants included eighteen male and twenty-seven female students who belonged to diverse nationalities including New Zealand, South Korea, Japan, Indonesia, Malaysia, Vietnam and Cambodia. None of them had any previous experience of learning Mandarin Chinese. The investigation involving the forty-five participants included the need to know their primary language and other languages spoken. As a result, with regards to primary language, twenty-three students spoke English; eighteen students spoke Korean; two students spoke Vietnamese; one student spoke Cambodian and one spoke Malay. In respect to other languages spoken fluently, twenty-one students spoke English as the additional language; six students spoke respectively Japanese, Spanish, Afrikaans, Tongan, Indonesian and Malay as the additional language; eighteen students as monolingual speakers did not speak any other language.

Hence, there are a total of twenty-seven bilingual speakers in this study, including eighteen Korean speakers, two Vietnamese speakers and one Cambodian speaker who spoke English as their second language, as well as six English speakers, each of whom spoke different second languages. The twenty-one students who spoke English as a second language have lived in New Zealand from 3 to 15 years with the majority having stayed in New Zealand for more than 10 years. These twenty-one students have a high/advanced level of English language proficiency as they have officially met the academic English proficiency requirement for study at the University of
Auckland. The remaining six bilinguals who spoke English as their first language and another language as their second language had rather more mixed levels of proficiency in that second language. They have learnt their second languages either from parents at home, or at high school. Although they have self-reported a high level of proficiency in their second languages, the degree of their second language proficiency is not as easy to determine or guarantee. Therefore, the twenty-seven students are broadly defined as bilingual speakers in this study (See the broad definition of bilingualism in 1.4.3.1)

The ages of the forty-five participants ranged from eighteen to forty-one years old. The education level of the participants was of a comparable level, and the majority were first-year university students with diverse academic interests, e.g., language, commerce, law, engineering. Twelve students had a language major, thirteen a language minor and none had a major in music. Some of the participants had different backgrounds in music while some had similar backgrounds. The different types of musical backgrounds are specified in the questionnaire section below. All participants had normal, or corrected to normal, sight and hearing. There were some differences in the levels of participants’ musical experience (ME)\textsuperscript{7} : some had different years of ME, but others did not or just had a little. The specific group divisions of learners’ ME will be presented in section 2.4.2.1 below.

2.4.2. Instruments

Four instruments were utilized to evaluate the extent to which the MA of the learners might affect their Mandarin lexical tonal perception and production. In other words,
whether learners’ MA helps in their Mandarin lexical tonal perception and production can be evaluated.

2.4.2.1. A questionnaire

A questionnaire was devised to indicate the participant’s language experience (LE) and musical experience (ME). The LE included information on an individual’s primary language, other language(s) spoken fluently, language environment where he/she lived, parents’ ethnicity, years of study and academic major as well as minor at UoA. The ME included an individual’s (non)experience of musical instruction, the age of onset of musical instruction, the years of having musical instruction, types of musical instrument and number of years played, non (experience) of vocal musical instruction, participation in other musical activities in addition to musical instruction, participation/membership of musical performance organisation(s) such as, for example, solo recitals, orchestra, chamber group, or band.

In light of the different levels of ME, which is the learned/trained aspect of MA, the raw data collected from the questionnaire resulted in the following grouping pattern of the 45 participants.

**Grouping Pattern: A total of three groups**

(1) Seventeen students who had no or little ME;

(2) Eighteen students who had received both formal instrumental and vocal musical instruction for less than ten years;

(3) Ten students who had received both formal instrumental and vocal musical instruction for more than ten years.
This grouping of learners’ ME (i.e. learned/trained MA) was nominally correlated with learners’ innate MA test scores, and MLT and MST scores (to be introduced in the following sections). One purpose of this statistical analysis was to evaluate whether ME will be interwoven with innate MA, so that musical aptitude could be clearly defined. This corresponds to RQ #1. The other purpose of this nominal correlation is to assess whether ME as the learned/trained MA has a significant correlation with learners’ tonal perception and production, which responds to one part\(^8\) of RQ #2.

Furthermore, another purpose of the questionnaire is to qualitatively discriminate monolingual speakers (MS) from bilingual speakers (BS). In particular, the questionnaire will serve to investigate whether learners’ language experience in the form of bilingualism plays a role in learners’ tonal perception and tonal production. This intention will be achieved by comparing and contrasting 27 BS in contrast with 18 MS. The results from this statistical analysis respond to RQ #4, so that in addition to MA whether another potential factor-learners’ bilingualism may play a role in their Mandarin tonal perception and tonal production, will be discovered.

**2.4.2.2. An innate musical aptitude (MA) composite test**

So that the different levels of the students’ innate MA could be identified an innate MA composite test was applied in order to assess the scores of participants’ innate MA test.

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\(^{8}\) The Results & Analysis Chapter will show that MA is defined here as a combination of innate MA and learned/trained MA which is ME. Since RQ #2 explores the correlation between MA including both innate MA and ME and learners’ tonal perception, as well as between MA and their tonal production, the correlation results from ME and learners’ tonal perception, as well as tonal production, only answer part of RQ #2. The other part, which is the correlation between innate MA and tonal perception, as well as tonal production, will be introduced in section 2.4.2.2 below.
Before introducing the innate MA test, the definition of innate MA needs again to be clarified. Musical aptitude (i.e. having a fine ear for music) is the innate ability to intuitively learn or appreciate music, and especially to distinguish off-key and off-pitch music (Gordon 1965). The alternative view suggests that the ability to appreciate and to understand music does not require any musical training, and people with musical talent have certain regions of the brain that are more developed than other people (Gordon, 1965; Patel, 2008). Two musical aptitude batteries—the *Seashore Measures of Musical Talents* (1960) and Gordon’s *Musical Aptitude Profile* (MAP) (1965), support the innate nature of musical aptitude definition and are the most widely acknowledged and commercially available in the world. The *Seashore Measures of Musical Talents* (1960) is composed of six subtests: Pitch, Loudness, Rhythm, Time, Timbre, and Tonal Memory. Whereas MAP is composed of seven subtests categorized into three divisions: 1) Tonal Imagery (Melody and Harmony subtests), 2) Rhythm Imagery (Tempo and Meter subtests), and 3) Musical Sensitivity (Phrasing, Balance, and Style subtests). It can be seen that there are different aspects of innate MA and most MA batteries contain different subtests. It is not likely though that most researchers will need to include all subtests of a battery in their studies. For this reason, it is crucial for researchers to examine whether the target battery has the most compatible subtest for the particular aspect of language under investigation (Gilkinson & Knower, 1939).

As neither Seashore’s battery nor the MAP battery will be adequate for evaluating all the important phonetic correlates of Mandarin lexical tone, which are pitch height, pitch contour, amplitude/loudness and duration/time (as shown in section 1.4.2.2 in the Introduction Chapter), the selected subtests from both MA batteries, which correspond to the important acoustic correlates of Mandarin lexical tone, were jointly
tested in the pilot study, and were applied in the main study as well. The joint subtests constitute the innate MA (composite) test in this study. Specifically, the Seashore Pitch, Loudness and Time subtests were used to assess pitch height, amplitude and duration, and the MAP Melody (melodic contour) subtest were utilised to assess pitch contour. In doing this, all important phonetic correlates of Mandarin lexical tone correlate with these selected musical subtests. The composite full score from these four subtests is 190. By trialling these subtests in the pilot study their appropriateness for the main study was assessed and determined. The specific application of these subtests is elaborated as follows.

2.4.2.2.1. Seashore Pitch subtest (1960)

In the test for the sense of pitch, fifty pairs of tones are presented. In each pair the listener is to determine whether the second tone is higher or lower in pitch than the first. The stimuli are derived from a beat-frequency oscillator through a circuit producing pure tones lacking in harmonics and over tones. The tones are at about 500 cycles and have a duration of .6 seconds. This subtest focuses on pitch height H(high)/L(low); it requires subjects to hear two tones which differ in pitch height, and then to judge whether the second is higher or lower than the first. Section 1.4.2.2.1 in the Introduction Chapter has shown that pitch height is one of the primary phonetic correlates of Mandarin lexical tone, and therefore this Pitch subtest focusing on pitch height links to this acoustic cue. For this reason, the Seashore Pitch subtest was tested in my pilot study and will accordingly be attested for my main study.
2.4.2.2.2. Seashore Loudness subtest (1960)

Fifty pairs of tones are presented in this subtest. The subject is to indicate for each pair whether the second tone is stronger or weaker than the first. Stimuli are derived from the same apparatus that is used for the pitch test, but the frequency is held constant at 440 cycles. Section 1.4.2.2.3 in the Introduction Chapter indicated that amplitude/loudness is one of the secondary phonetic correlates of Mandarin lexical tone, and therefore this Loudness subtest links to this acoustic cue. For this reason, the Seashore Loudness subtest was tested in my pilot study, and was accordingly utilised in the main study.

2.4.2.2.3. Seashore Time subtest (1960)

The test for the sense of time consists of fifty pairs of tones of different duration. The subject is to determine whether the second tone is longer or shorter than the first. The source for the stimuli is the oscillator used in the pitch test. The duration of the tones is controlled automatically by a tape timing device for which the tape has been prepared with a predetermined schedule of time intervals. The frequency of the tones is held constant at 440 cycles. Section 1.4.2.2.2 in the Introduction Chapter indicated that time/duration/length is one of the secondary phonetic correlates of Mandarin lexical tone, and therefore this Time subtest links to this acoustic cue. For this reason, the Seashore Time subtest was tested in my pilot study, and was accordingly used in the main study.

2.4.2.2.4. MAP Melody subtest (1965)

A melody in the music is a series of tones sounding in succession. In Gordon’s MAP (1965), the Melody subtest mainly assesses melodic contour of short musical phrases,
which corresponds to the pitch contour of Mandarin lexical tone. The MAP Melody subtest has 20 pairs of items. This test was not concerned with the historical or technical facts about music, but the participants were asked to compare a musical answer with a musical question performed on the violin. The musical questions and musical answers consist of short musical phrases rather than an unmusical isolated series of pitches. In each case, the musical answer contains more pitches than the musical question. If the added pitches are removed from the musical answer, the musical answer would sound exactly the same as the musical question.

The participants were asked to decide whether the musical answer was like or different from the musical question (i.e. if the musical answers were in the same tonal category or not). The musical answer is like the musical question if it is a melodic variation of the musical question. The musical answer is different from the musical question if it is not a melodic variation of the musical question. The students had an answer sheet on which to indicate his/her choice. If the student was not sure of the answer to a given exercise, he/she was instructed to mark the question-mark (?) column, indicating that he/she was "in doubt." In this way, the students were not forced to make judgments on all questions. In other words, participants only answered those questions which they felt capable of answering. Throughout the battery, musical questions and musical answers are referred to as songs and pitches are referred to as notes in the test directions. The subtest goes beyond isolated pitch discrimination, which is merely a matter of acoustical perception, because the Melody subtest also measures sensitivity to melodic contour, which is more pertinent and basic to music itself. In making the simple decision of like or different, the student does not need to count tones or to be familiar with musical concepts such as modulation. Section 1.4.2.2.1 in the Introduction Chapter has shown that pitch contour is one of the
primary phonetic correlates of Mandarin lexical tone, and therefore the Melody subtest mainly assesses this acoustic cue. For this reason, this subtest was tested in my pilot study, and was accordingly applied to my main study as well.

As a whole, we can see that in order to evaluate all important phonetic cues of Mandarin lexical tones (i.e. pitch height, pitch contour, amplitude, duration), three subtests from Seashore (i.e. Pitch, Loudness, Time) and one Melody subtest from Gordon’s MAP need to be combined as a joint new innate MA (composite) test/battery. Their applicability has been tested in the pilot study, so that their appropriateness has ultimately been determined for the main study. Finally, the overall composite scores of the innate MA test battery and the separate scores from each subtest will be correlated to the scores of the following MLT and MST. The former correlation between MA composite scores and MLT, as well as MST, evaluates the correlation between learners’ innate MA and Mandarin lexical tonal perception, as well as tonal production. This corresponds to the other part of RQ #2 (See Footnote 8). In combination with the statistical analysis on the aforementioned correlation between ME (i.e. learned/trained MA) and learners’ tonal perception, as well as production, RQ #2 regarding the correlation between learners’ MA including both innate MA and ME and learners’ tonal perception, as well as production, will be fully investigated. The latter correlation between separate subtest scores and MLT, as well as MST, responds to RQ #3 which assesses which aspect of MA has the strongest correlation with MLT and MST respectively.

Finally, the innate MA test will be carried out again at the later stage testing in order to compare and contrast learners’ performance at both stages of testing, as well as to assess its correlation with MLT and MST during the later stage testing. This responds
to RQ #5 which assesses whether the potential effect of MA in learners’ tonal perception and production changes over time.

2.4.2.3. A Mandarin lexical tone listening test (MLT) for perception

This MLT was designed to assess how learners perceive target Mandarin lexical tones. It is composed of 54 lexical tone items including 25 monosyllables and 29 disyllables, which are extracted from Sanders & Yao (2009). The selected 54 lexical tones contain 29 known words (i.e. words that were taught to students within the first three weeks of 2012 semester 1) and 25 unknown words (i.e. words that were not taught in the 2012 semester 1 course). Lexical neutral tone and tone Sandhi items were included in disyllables. However, we should be aware that if a student correctly identifies the tone of a known vocabulary item, it will still not be known if this is because s/he is ‘hearing’ the tone correctly or is simply mentally ‘seeing/recalling’ the tone mark written correctly on the textbook page.

There are two versions of Mandarin lexical tone listening test: a student’s version and a teacher/researcher’s version. The student’s version is comprised of 54 lexical syllables without tone marks; students were asked to listen and distinguish the target tone by selecting the right pitch contour on the test paper. The test was used to assess if participants would be able to perceive the target tones appropriately or label syllables into the right tonal categories. The teacher/researcher’s version is composed of 54 lexical syllables with tone marks, which were used to make a recording for the listening test, which then provided a marking criterion for the participant’s test results. In sum, the listening test results were correlated with the innate MA test composite scores, and with three groups of learners’ ME, as well as with separate scores from
each MA subtest including Pitch, Loudness, Duration and Melody. Doing these correlations tests aim to evaluate whether MLT has a significant correlation with innate MA and ME, as well as which subtest of MA has the strongest correlation with the MLT for tonal perception. An MLT was also used to compare and contrast bilingual speakers with monolingual speakers, which has been introduced in detail in section 2.4.2.1 above. Finally, an MLT was used once again during the later stage testing in order to compare and contrast learners’ performance at both stages of testing, as well as to assess its correlation with the MA and MST during later stage testing.

2.4.2.4. A Mandarin lexical tone speaking test (MST) for production

This MST was designed to evaluate how learners produce target Mandarin lexical tones. In order to compare the extent of musical effect taking place in learners’ perception and their production, I applied the same 54 lexical tone items (from the listening test) to the speaking test. There was only one version available for both participants and the teacher/researcher. The one-to-one speaking test requires each participant to read each item according to the given test paper, which will be audio-recorded. Finally, the recording was not transcribed, but assessed to mark a score through listening only. In order to maintain the consistency, reliability and validity of the assessment, the speaking test was assessed to be right or wrong by the researcher (i.e. I), who has been teaching Mandarin Chinese at the University of Auckland for seven years. If any tonal item was marked as correct, then a full score for that tonal item was given; if any tonal item was marked as wrong, then a zero score for that tonal item was given. In doing so, whether participants were able to produce the target lexical tones correctly was evaluated.
In sum, the speaking test results were correlated with the innate MA test composite scores, and with three groups of learners’ ME, as well as with separate scores from each MA subtest, including Pitch, Loudness, Duration and Melody. These correlation tests aimed to evaluate whether the MST has a significant correlation with innate MA and ME, as well as which subtest of MA has the strongest correlation with the MST (for tonal perception). The MST will also be used to compare and contrast bilingual speakers with monolingual speakers, which was introduced in detail in section 2.4.2.1. Finally, the MST was once again be administered during the later stage testing in order to compare and contrast learners’ performance at both stages of testing, as well as to assess its correlation with MA and the MLT during later stage testing.

2.4.3. Test setting

In general, all of the tests including the questionnaire, the innate MA (composite) test, MLT, and MST were conducted outside the learners’ regular class time. However, the questionnaire, the innate MA test and the MLT were all conducted in a classroom setting, and during which the listening recordings were played on the computer in the classroom. The classroom capacity was approximately 60~70 students. The one-to-one MST was conducted in a seminar room with a capacity of 5~10 students.

Tests were administered in a room that had good acoustics and where there was no noise disturbance either in the room or in adjacent areas. For such a large group, good test conditions are particularly important; the acoustics must permit the stimulus sounds to be heard clearly in all parts of the room. No one sat closer to the loud speaker than 1.524 meters. When one sits closer, one hears more of the surface noise from the recording and electronic noises from the amplification system.
2.4.4. Procedure

There were two rounds of data collection, each of which took place at two different stages. During the early stage of the first semester of learning, I conducted three tests with participants on three occasions respectively: a questionnaire and an innate MA test on the first occasion, a MLT on the second occasion, and a MST on the third occasion. Concurrently, qualitative data collected from the questionnaire revealed three groups of learners’ ME which were correlated with their innate MA test, MLT and MST. In doing so, an appropriate definition of musical aptitude can be achieved, and the relationship between the learners’ MA (i.e. innate MA + learned/trained MA) and their tonal perception, as well as their tonal production, can identified independently. Furthermore, which MA subtest has the strongest correlation with MLT and MST respectively can be explored. Finally, in addition to MA, learners’ learning experience in the form of bilingualism can be examined to establish what role it might play in tonal perception and production.

Toward the end of learners’ first semester of study, the MA test, the MLT and the MST were conducted once again on another three occasions. The purpose of doing so was to assess after an entire semester of students’ intensive learning the extent to which the tonal learning experience impacts on their Mandarin tonal perception and production, and whether their tonal perception and production significantly improve. There is a necessity to clarify that the students’ intensive learning was built upon 60 learning hours in the formal teaching classroom, and their training conditions were both communicative and instructional, with the foci on both form and meaning. In short, the effect of MA in learners’ tonal perception and production were evaluated in
a longitudinal study, where whether learners’ MA helps in their tonal perception and production over time can be investigated.

The specific procedures of data collection are introduced below:

2.4.4.1. Early stage testing

First occasion

Three weeks after beginning their Chinese Stage I course, participants were asked to complete one questionnaire and a follow-up musical aptitude composite test. On the day, they were supplied with a copy of the special answer sheet on which to record their responses. The students were asked to fill out the questionnaire first and then begin the innate musical aptitude test including three Seashore Pitch, Loudness, and Time subtests, and a MAP Melody subtest. Finally, the questionnaires and musical aptitude test papers were collected and assessed by the researcher. The application of the collected data from the questionnaire and the musical aptitude test scores was described in detail in sections 2.4.2.1 and 2.4.2.2.

Second occasion

On the second day of the fourth week, I conducted a Mandarin tone listening test with students in a regular classroom. Participants were asked to listen and distinguish which was the target tone by selecting (circling) the right pitch contour on the test paper of the student’s version. Finally, the test papers were collected by the researcher and the scores were marked based on the teacher/researcher’s version. The application of the collected data from the MLT was described in detail in sections 2.4.2.3.
From the third day to the fifth day during the fourth week (3 consecutive days) of the semester, I administered a one-to-one Mandarin tone speaking test with each participant in a seminar room. On the day, each participant was asked to read each item of the 54 lexical tones aloud and their reading production was recorded. As there were 45 participants, the total working time for all the participants was 3 consecutive days (15 participants per day). The recordings were transcribed, but scores were assessed through listening only. The application of the collected data from the MST was described in detail in sections 2.4.2.4.

2.4.4.2. Later stage testing

By the thirteenth week of the semester (i.e. 60 classroom hours = 5 classroom hours per week* over 12 weeks; the training conditions were both communicative and instructional), the musical aptitude test, Mandarin lexical tone listening test and Mandarin lexical tone speaking test were conducted once again in order to detect any changes that may have taken place to participants over the preceding few weeks. Specifically, SPSS paired T-tests were utilized to compare and contrast the early stage testing with the later stage testing. Subsequently, SPSS Spearman bivariate correlations were undertaken to assess whether learners’ MA correlated with their tonal perception and production. In doing so, whether the potential impact of learners’ MA on their tonal perception and production had changed over time was investigated. Specifically, after learning Mandarin tones for twelve weeks, the repeated tests aimed to investigate:

a. whether the learners’ performance on the musical aptitude test would reveal major changes: if it did, then the relationship between the learners’ musical tonal
experience (i.e. the entire semester 1) and their musical aptitude could be evaluated;
b. whether the learners’ performance on the Mandarin tones listening test would show significant improvement as their tonal learning experience increases.
c. whether the learners’ performance on the Mandarin tones speaking test would reveal significant improvement as their tonal learning experience increases.

2.4.5. Data analysis

The research was divided into two stages: early stage testing and later stage testing. The five research sub-questions serve to respond to the over-arching main research question. Specifically, RQ #1 highlights the need to define MA in a robust manner because it is crucial to conducting the current research. An appropriate definition of MA will be created as a result of evaluating RQ #2.

RQ #2 addresses the association between learners’ and their lexical tonal perception, as well as between MA and their tonal production, in the early stage testing. This research question is addressed by conducting two types of statistical analysis: SPSS Spearman bivariate correlations were conducted between the innate MA and MLT, as well as between the innate MA and MST; while SPSS Spearman nominal correlations were undertaken between ME (i.e. learned/trained MA), the innate MA, MLT and MST. More specifically, on the one hand, the SPSS Spearman bivariate correlations were conducted between the innate MA test scores and MLT scores, as well as between innate MA test scores and MST scores. The rationale for selecting the Spearman rather than the Pearson correlation is that the collected data from the three tests were nonparametric (Field, 2009). In other words, in the main study the data is not normally distributed in the innate MA test, and MLT and MST. On the other hand, one grouping pattern of ME, which is learned/trained MA, was qualitatively evident.
in the responses to the questionnaire. This grouping, with a total of three groups, was nominally correlated with the learners’ innate MA test scores, and MLT and MST scores. Similarly, SPSS Spearman nominal correlations were undertaken between learners’ ME (i.e. learned/trained MA) and their tonal perception, as well as ME and tonal production. The rationale for selecting the Spearman rather than the Pearson correlation is once again that the collected data from learners’ ME is nominal/categorical (Field, 2009). The results from the above tests not only can help to answer RQ #1 that seeks to elaborate the definition of MA, but also to reveal if there is a significant correlation between learners’ MA (i.e. innate MA + ME) and learners’ tonal perception, as well as tonal production. In other words, whether the MA of learners helps in their Mandarin tonal perception and production in the early stage testing can be explored.

In response to Research Question #3, the four subtests for Pitch, Melody, Loudness and Time comprise the MA composite profile. To examine which subtest has the strongest correlation/association with the learners’ MLT and MST, each of the four subtests were bivariate-correlated with the MLT and MST respectively.

To respond to RQ #4, 27 bilingual speakers were compared and contrasted with 18 monolingual speakers on their tonal perception and production (See section 5 in Results and Analysis Chapter). Using SPSS Independent T-tests, the results of the MA test, the MLT and MST of bilingual speakers and monolingual speakers, were compared and contrasted respectively. Doing these tests aid in providing the answer for RQ #4 in regard to whether other factor(s) play(s) a role in learners’ tonal perception and production.

The following is in regard to RQ #5. By the thirteenth week of the semester, SPSS paired T-tests were carried out to compare and contrast learners’ early stage
performance on the MA test, and MLT and MST with their performance during the later stage testing. Subsequently, SPSS Spearman bivariate correlations were conducted once again in the later stage testing in order to evaluate the correlation between the learners’ innate MA and their MLT, as well as between their MA and MST. In doing so, the effect of MA in learners’ perception and production were further investigated over an extended period of time. In short, if MA is a factor in Mandarin tone perception and production and whether its impact changes over time was explored. This exploration assists in responding to the main research question about whether musical aptitude helps NNS’ perception and production of Mandarin lexical tones at later stage testing. If it does help at the early stage of learning, whether this helpful impact is sustained over time will be investigated in the longitudinal study.

2.5. Summary of the chapter

The pilot study assisted in determining and refining the main research question and the five sub-research questions, and the research procedure, and research instruments including a questionnaire, an innate MA composite test, a MLT and a MST. With the solid foundation provided by the outcomes of the pilot study, the main study utilized the resultant refined research instruments, research procedures and research questions, as well as data analysis, to diagnose the potential effect of MA in Mandarin lexical tonal perception and tonal production by NNS of Chinese. The collected data were analysed using a total of four instruments including a questionnaire, an innate MA test, a MLT and a MST. The data collected by these four instruments were analysed by the following four statistical methods: SPSS Spearman bivariate correlation, Spearman nominal correlation, Independent T-tests, and Paired T-tests. The next chapter, which is the Results and Analysis Chapter, will reveal and analyse the six key research findings from both stages of testing in the main study.
Chapter 3: Results and Analysis

3.1. Overview of the chapter

By using the results from a questionnaire, an innate\textsuperscript{9} musical aptitude (MA) composite test, a Mandarin lexical tone listening test (MLT) and a Mandarin lexical tone speaking test (MST), this chapter will demonstrate and analyse the results from both the early stage testing and the later stage testing. The purpose of the tests was to evaluate whether MA helps NNS of Chinese in their perception and production of Mandarin lexical tones. In other words, the relationship between learners’ MA\textsuperscript{10} and their Mandarin lexical tonal perception, as well as between MA and tonal production, was examined at both stages of testing. The SPSS Spearman bivariate correlation, Spearman nominal correlation, Independent T-tests and Paired T-tests were primarily utilised to analyse the collected data. A total of 6 key findings emerged from this study.

The section immediately below begins with an introduction to the learners’ language and musical background, as well as their different tests’ scores from the early stage testing. It then goes on to provide the researching analysis with their 4 key findings, and finally a summary of the early stage test findings will be provided. In section two, an introduction to the later stage testing is presented; this is followed by an analysis of the 2 key findings. Finally, in order to provide an overview of how the effect of learners’ MA in their MLT and MST has altered in this longitudinal study, a summary of the later stage testing and a summary of the overall 6 research findings from both the early and later stage testing are presented. Both in summary and to provide

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\textsuperscript{9} The word ‘innate’ is to highlight the innate aspect of MA that the MA composite test supports.
\textsuperscript{10} MA is defined as a combination of innate MA and learned/trained MA which is ME in this study. This definition is discussed in detail in section 4.3.2.3 of Discussion Chapter.
context the research questions are listed, each of which is followed by the corresponding key findings.

**Main research question:**

Does musical aptitude help non-native speakers of Chinese in their perception and production of Mandarin lexical tones at different stages of their learning?

**Research sub-questions:**

RQ #1: How should musical aptitude (MA) be defined?

- Key Findings #1 and #2 jointly respond to RQs #1 and #2.

RQ #2: Is there a significant correlation between non-native speakers (NNS)’ MA and their perception and production of Mandarin tones?

- Key Findings #1 and #2 jointly respond to RQs #1 and #2.

RQ #3: What aspect of MA provides the most advantage in NNS’ tonal perception and tonal production respectively?

- Key Finding #3 responds to RQ #3.

RQ #4: Are there other factors in addition to MA that play a role in NNS’ Mandarin tonal perception and production?

- Key Finding #4 responds to RQ #4.

RQ #5: If MA is a factor in Mandarin tone perception and production, does its impact change over time?

- Key Findings #5 and #6 jointly respond to RQ #5.
Early Stage Testing

3.2. Introduction

The ME and LE patterns in the response to the questionnaire were introduced in section 2.4.2.1 of the Methodology Chapter. The innate MA test scores ranged from 77 to 182 out of a total score of 190; MLT scores ranged from 28 to 78 out of a total score of 83; their MST scores ranged from 34 to 82 out of a full score of 83.

In the early stage testing, the following data analyses were conducted: 1) learners’ innate MA test scores were bivariate-correlated with their MLT scores, the aim being to evaluate the relationship between innate MA and Mandarin tonal perception; 2) the learners’ innate MA test scores were bivariate-correlated with their MST scores, the purpose being to discover the relationship between innate MA and Mandarin tonal production; 3) learners’ MLT scores were bivariate-correlated with their MST scores, which aimed to establish what kind of correlation level each had with the other; this test finding was not the focus but a by-product of tests 1) and 2), which are not discussed in detail in this study; 4) SPSS Spearman nominal correlations were analytically conducted between learners’ three levels of ME (i.e. learned/trained MA) and their innate MA test scores, MLT and MST. The intricate relationship between learners’ innate MA and their ME aided in elaborating the definition of MA; at the same time, together with the findings from analyses 1) and 2), the findings from this nominal correlation test helped to assess whether there was a significant correlation between learners’ MA (i.e. innate MA + ME) and their tonal perception, as well as between MA and tonal production, in the early stage testing; 5) each subtest from the MA composite test (i.e. pitch, time, duration, melody) was respectively correlated to MLT and MST, the purpose of which was to evaluate which aspect of MA provides
the most advantage to learners’ tonal perception and production respectively; 6) using SPSS Independent T-tests analysis, the group monolingual (MS) and bilingual speakers (BS) was compared. The purpose of this analysis was to discover in addition to MA whether learners’ LE in the form of bilingualism affected their tonal perception and production as indicated in prior studies (See section 1.4.3.1 in the Introduction Chapter). The following 4 sections, based on the sequence presented above, will analyse each of the findings from the early stage testing.

3.2.1. Key Finding #1: The effect of innate MA on tonal perception and production  (Together with Key Finding #2, responding to RQs #1 and #2)

The innate MA test scores were correlated with MLT scores and MST scores respectively, the aim being to discover the relationship/association between learners’ innate MA and their perception and production of Mandarin lexical tones. The findings indicate a significant, medium/moderate positive correlation between learners’ innate MA and their MLT performance, as well as between their innate MA and MST performance. The level of association that existed between the learners’ listening and speaking performance for the target Mandarin lexical tones was observed as a by-product of the former two test analyses. The finding showed a strong positive correlation between MLT and MST.
Table 3.1  Correlations between innate MA, MLT and MST

<table>
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<th>Composite</th>
<th>MLT</th>
<th>MST</th>
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<td>Spearman's rho</td>
<td>Innate MA</td>
<td>Correlation Coefficient</td>
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<td>Sig. (2-tailed)</td>
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<td>.023</td>
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<td>Correlation Coefficient</td>
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<td>Sig. (2-tailed)</td>
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<td></td>
<td>MST</td>
<td>Correlation Coefficient</td>
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<td>Sig. (2-tailed)</td>
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* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Figure 3.1: Positive Moderate Correlation between innate MA and MLT

The association between the learners’ innate MA test performance and their MLT was assessed to be at the significantly moderate/medium level. Specifically, the correlation coefficient $r$ between learners’ innate MA test and their MLT was 0.359 and its P-value was 0.015 < 0.05, which is statistically significant at the 0.05 level (See Table
It seems that the higher learners’ innate MA was, the better they tended to perform in the MLT. This result suggests a positive medium association between learners’ innate MA and their MLT performance; the medium level of the association is similarly depicted in the distribution of scatter plots in Figure 3.1. On the other hand, the correlation coefficient r is in itself a measure of effect size. For the purpose of comparison with other measures of effect size, r is squared to obtain R² which suggests a medium effect if it is situated between 1-10 per cent and a big effect if it is over 10 per cent (Pallant, 2010). In this case, the two variables correlated to r 0.359, and the significance at p<0.05 which, when squared, becomes R²=0.1288 or 12.9 per cent, and therefore similarly indicates a positive medium effect. Hence, the innate MA can explain 12.9 per cent of the variance in the MLT scores. This implies that there are other uncontrollable variables affecting the learners’ MLT performance, such as learning styles, learning intensities, learning strategies, gender and assessment anxieties (Horwitz et al., 1986; Holmes, 2001). However, since the focus of this study is not these uncontrollable factors, but the strength of correlation between innate MA and MLT, as well as MST, these uncontrollable factors will not be further examined here.
The association between the learners’ innate MA test performance and their MST was also assessed to be at the significantly moderate/medium level. Specifically, the correlation coefficient between the learners’ innate MA and their MLT was 0.338 and its P-value was 0.023<0.05, which is statistically significant at the 0.05 level (See Table 3.1). It seems that the higher the learners’ innate MA, the better they tended to perform in the MST. This result suggests a positive medium association between the learners’ innate MA and their MST performance; this medium level of association is similarly reflected in the distribution of the scatter plots in Figure 3.2. The two variables correlated to r 0.338, and the significance at p<0.05 which, when squared, becomes R²=0.1142 or 11.4 per cent, and therefore similarly indicates a positive medium effect. Hence, the innate MA can explain 11.4 per cent of the variance in the MST scores. This implies that there are other uncontrollable variables affecting learners’ MST performance, such as their learning styles, learning intensities, learning strategies, gender, and assessment anxieties (Horwitz, 1986; Holmes, 2001). However,
since the focus of this study is not these uncontrollable factors but the strength of correlation existing between innate MA and MLT, as well as MST, these uncontrollable factors will not be further examined here.

**Figure 3.3: Positive Strong Correlation between MLT and MST**

Finally, the association between the learners’ MLT and MST was observed as a by-product of the preceding two findings, which revealed a significant strong/large level of correlation. Specifically, the correlation coefficient between the learners’ MLT and their MST was 0.837 and its P-value was .000, which is statistically significant at the 0.01 level (See Table 3.1). Thus the higher the learners’ MLT scores, the better they performed on the MST. As reflected in the distribution of scatter plots in Figure 3.3, this result suggests that a positive large association exists between the learners’ MLT and their MST performance. The MLT and MST correlated to r 0.837, and the significance was at p<0.01 which, when squared, becomes $R^2=0.7006$ or 70.1 per cent, and therefore similarly indicates a positive strong effect. Hence, the MLT can explain 70.1 per cent of the variance in the MST scores, which reveals that the MLT
performance plays an influential role in the MST, and vice versa. Since this test finding was not the focus but a by-product of bivariate correlation tests between the innate MA test and MLT, as well as between the innate MA test and MST, this correlation result will not be discussed further in this study.

Figure 3.4: Overall Correlations between innate MA, MLT and MST

As a whole, during the early stage testing, the correlation between the innate MA test and the MLT, as well as between the innate MA test and the MST, demonstrated a positive medium effect, which is statistically significant. This finding reveals that the association between learners’ innate MA, their MLT and MST was neither strong nor weak, but placed in the middle. This implies that the learners’ innate MA may not be the determining factor but could be considered as one of the significant factors affecting learners’ MLT and MST. In other words, learners’ innate MA plays a role in their listening and speaking of Mandarin lexical tones and this role cannot be neglected. The learners’ MLT and MST were found to be highly correlated with each other, which accounts for the crucial role of learners’ MLT in their MST; the same is
true for the significant role of MST in MLT. The overall correlations are reflected in the distribution of scatter plots in Figure 3.4. Key Finding #1 overall indicated a significant, positive medium effect of the innate aspect of MA on NNS’ perception and production of Mandarin lexical tones. In order to further discover the effect of the other aspect of MA, which is learned/trained MA (i.e. ME) on learners’ tonal perception and production, and also whether learners’ innate MA was strongly interwoven with their ME, the learners’ different levels of ME (i.e. learned/trained MA) were, as indicated in the following section, nominally correlated with their innate MA, MLT and MST. Hence, together with Key Finding #1, Key Finding #2 will ultimately seek an appropriate definition of MA, and assess whether there was a significant correlation between learners’ MA as a combination of innate MA and ME and their tonal perception, as well as between MA and tonal production.

3.2.2. Key Finding #2: Definition of MA & the effect of ME on tonal perception and production

(Together with Key Finding #1, responding to RQs #1 and #2)

ME was found to have a strongly significant, positive moderate/medium correlation with innate MA, which indicates that innate MA and ME have an intricate relationship. This interwoven relationship between ME and innate MA ultimately helped to define MA. Concurrently, ME had a significant, moderate/medium correlation with tonal perception, but had a weak/small correlation with tonal production, which was not statistically significant. In other words, compared to innate MA, ME plays an equal role in learners’ tonal perception, which however seemed not to be the case in regard to tonal production.

A total of 3 groups

(1) Learners who had no, or little ME:
(2) Learners who had received both formal instrumental and vocal musical instruction for less than 10 years;

(3) Learners who had received both formal instrumental and vocal musical instruction for more than 10 years.

Table 3.2 Correlations between innate MA, MLT, MST and ME

<table>
<thead>
<tr>
<th>Musical Experience on 10-year division 3</th>
<th>Innate MA</th>
<th>MLT</th>
<th>MST</th>
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</thead>
<tbody>
<tr>
<td>Mann's rho</td>
<td>Correlation Coefficient</td>
<td>Sig. (2-tailed)</td>
<td>N</td>
</tr>
<tr>
<td>Innate MA</td>
<td>.403**</td>
<td>.006</td>
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<tr>
<td>MLT</td>
<td>.331*</td>
<td>.026</td>
<td>45</td>
</tr>
<tr>
<td>MST</td>
<td>.269</td>
<td>.074</td>
<td>45</td>
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</table>

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The association between the learner’s innate MA test performance and their ME was moderate/medium significance. Specifically, the correlation coefficient $r$ between learners’ innate MA test performance and their ME was 0.403 and its $P$-value was $0.006<0.05$, which is statistically significant at the 0.01 level (See Table 3.2 above).
Higher levels of learners’ innate MA were moderately associated with being in a higher group (with more musical instruction). This result implies that learners’ innate MA was interwoven with their ME, which foreshadows musical aptitude as a combination of innate MA and ME (i.e. learned/trained MA). In addition, the learners’ ME was moderately correlated with their MLT. The correlation coefficient $r$ between learners’ ME and their MLT was 0.331 and its P-value was 0.026<0.05, which is statistically significant at the 0.05 level (See Table 3.2). Higher MLT scores were moderately associated with being in a higher group (with more musical instruction). This result indicated that ME had a significant moderate/medium effect on learners’ tonal perception. However, ME had a weak/small correlation with MST. The correlation coefficient $r$ between learners’ ME and their MST was 0.269 and its P-value was 0.074>0.05, which is not statistically significant (See Table 3.2). It seemed that higher MST scores were not necessarily associated with being in a higher group (with more musical instruction). This statistical result seems to unexpectedly contradict the findings of prior studies (See section 1.5.5 in the Introduction Chapter), which however does not mean learners’ ME was not associated with their tonal production, but could be explained by the small sample size of each of the three groups of ME.

In addition, it was also found that there were two participants who received formal vocal ME only. They performed better on the MST than did students who received formal instrumental ME only, and interestingly, the latter students performed better on the MLT than did the former students. These differences may imply that vocal ME may correlate with Mandarin tonal production, and instrumental ME may correlate with Mandarin tonal perception. In other words, different types of ME seemed to contribute in different ways to the perception and production of Mandarin lexical
tones. Obviously, the sample size of students with instrumental ME was much larger than those with vocal ME, which may account for the mixed research results that ME was significantly correlated with tonal perception, but not necessarily with tonal production. Overall, these mixed results imply the complexity and dynamics of the relationship between ME and the perception and production of Mandarin lexical tones in particular, and between MA (i.e. innate MA + ME) and the perception and production of Mandarin lexical tones in general. This complexity and the interwoven relationship between innate MA and ME, makes it difficult to tease innate MA and ME apart. Learners’ tonal perception and production may be partially influenced by their innate MA and partially affected by their external years of ME, which is learned/trained MA. The intertwined relationship of innate MA and ME aided in defining MA as a combination of innate MA and ME. This definition answers RQ #1. On the other hand, in order to respond to RQ #2, Key Findings #1 and #2 jointly show that there was a significant correlation between learners’ MA (i.e. innate MA + ME) and their tonal perception, as well as between their innate MA and their tonal production. Due to the small sample size there was, however, an insignificant, weak/small correlation between learners’ ME and tonal production. More specifically, the following section provides an analysis of which aspect of MA provides the most advantage to learners’ tonal perception and tonal production respectively.

3.2.3. Key Finding #3: Pitch of MA with tonal perception; Melody of MA with tonal production

(Responding to RQ #3)

Four subtests for Pitch, Melody, Loudness and Time comprise the innate MA composite test. To examine which subtest of the innate MA composite test has the strongest correlation/association with the learners’ MLT and MST, each of the four subtests was bivariate-correlated with the MLT and MST respectively, where each
The correlation was compared and contrasted. The results indicated that the Pitch subtest had the strongest correlation with the MLT, and that the Melody subtest had the strongest correlation with the MST. In other words, the pitch aspect of MA gives the most advantage in learners’ tonal perception, and the melody aspect of MA gives the most advantage in their tonal production.

**Table 3.3  Correlations between each subtest and MLT & MST**

<table>
<thead>
<tr>
<th>Spearmann's rho</th>
<th>Pitch Correlation Coefficient</th>
<th>Time Correlation Coefficient</th>
<th>Melody Correlation Coefficient</th>
<th>Loudness Correlation Coefficient</th>
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<td>.474**</td>
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*Correlation is significant at the 0.01 level (2-tailed).
As presented in Table 3.3, the correlation coefficients $r$ for the Pitch subtest, the Time subtest, the Melody subtest and the Loudness subtest with respect to the MLT were observed as 0.328, 0.205, 0.316, and 0.183 respectively. The data suggests that the Pitch subtest, of which the correlation coefficient $r$ was at 0.328 and the P value 0.028, had the strongest correlation with the MLT, which is statistically significant ($P<0.05$).

Table 3.3 reveals that the correlation coefficients that each of these four subtests received from the MST were 0.282, 0.292, 0.344 and 0.075 respectively. By comparison, it is notable that the Melody subtest, whose correlation coefficient $r$ was 0.344 and whose P value was 0.021, had the closest correlation with the MST, which is statistically significant ($P<0.05$).

These two findings reveal that among the four subtests, the Pitch subtest, which assesses pitch height, had the strongest association with MLT scores. This indicates that the participants in this study, who are NNS of Mandarin, directed their attention more to the pitch height and less to the pitch contour dimension (i.e. Melody subtest), in order to listen/perceive the target Mandarin lexical tones. With regard to the MST, the Melody subtest, which evaluated the pitch contour, appears to have the strongest relationship with the MST. This finding shows that the NNS participants in this study paid more attention to the melodic pitch contour and less to the pitch height (i.e. Pitch subtest) when speaking/producing the target Mandarin lexical tones. Overall, it seems that NNS learners of Mandarin lexical tones encountered more difficulty in perceiving the melodic pitch contour and accordingly had less difficulty in perceiving pitch height, whereas they appeared to have more difficulty in producing pitch height and less difficulty in producing a pitch contour. This implies that pitch height plays an important role in the perception of lexical tones by NNS, and that the melodic pitch
contour plays a crucial part in the production of tones by NNS. These results are consistent with those of previous studies which found that NNS perception appears to be determined by pitch height, whereas their production tends to be determined by the contour of the tones (e.g. Gandour, 1983; Shen, 1990; Wang et al., 2003; Young, 2010). In contrast, native Mandarin listeners attach slightly more importance to pitch contour than pitch height (Gandour, 1983; 1984; Wang et al., 2003), and native speakers utilise both the contour and height/register to determine tonal categories (e.g. Wang et al., 2003; Bent, 2005; Yang, 2010).

However, what needs to be addressed here is that these results reflect the study of monosyllables and disyllables in isolation only, which implies that pitch height and pitch contour are the most important acoustic cues for Mandarin monosyllables and disyllables. However, other acoustic cues such as time and duration could start to play equally important roles when the Mandarin tones are built, for example on different syntactical structures or sentences, intonation, stress, monolinguals/bilinguals, gender, age, geography, and speaker’s mood (Dow, 1972; Yip, 2002; Sanders, 2008).

3.2.4. Key Finding #4: Language experience in the form of bilingualism

(Responding to RQ #4)

As noted in prior studies (See section 1.4.3.1 in the Introduction and Literature Review Chapter), LE in the form of bilingualism plays a role in foreign or L2 language learning. In order to assess whether this case is true for Mandarin tone learning, 27 bilingual speakers were compared to the remaining 18 monolingual speakers in the innate MA test, MLT and MST. SPSS Independent T-tests were conducted to compare and contrast how those two groups (i.e. 27 BS vs. 18 MS) performed differently from one another in the MA test, and MLT and MST. The
results revealed that BS performed significantly better than did MS in the MLT and MST, although their performance on the MA test was not significantly different. Additionally, the study intended to assess how tonal language speakers perform differently from non-tonal language speakers, but unfortunately there were only 2 tonal language speakers in this study, both of whom were Vietnamese. Understandably, the extremely small sample size of tonal language speakers did not allow a significant statistical analysis to be carried out, and hence the performance of this TLS and NTLS will not be examined here

**Table 3.4  27 Bilingual Learners vs. 18 Monolingual Learners**

<table>
<thead>
<tr>
<th></th>
<th>mono vs. bilin</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>t-value</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA</td>
<td>monolingual speakers</td>
<td>18</td>
<td>154.44</td>
<td>17.727</td>
<td>4.178</td>
<td>-.298</td>
<td>41.441</td>
<td>.767</td>
</tr>
<tr>
<td></td>
<td>bilingual speakers</td>
<td>27</td>
<td>156.22</td>
<td>22.142</td>
<td>4.261</td>
<td>-.298</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MLT</td>
<td>monolingual speakers</td>
<td>18</td>
<td>49.06</td>
<td>11.669</td>
<td>2.750</td>
<td>-</td>
<td>38.516</td>
<td>.013</td>
</tr>
<tr>
<td></td>
<td>bilingual speakers</td>
<td>27</td>
<td>58.67</td>
<td>12.613</td>
<td>2.427</td>
<td>2.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MST</td>
<td>monolingual speakers</td>
<td>18</td>
<td>54.67</td>
<td>15.412</td>
<td>3.633</td>
<td>-</td>
<td>34.360</td>
<td>.010</td>
</tr>
<tr>
<td></td>
<td>bilingual speakers</td>
<td>27</td>
<td>66.96</td>
<td>14.141</td>
<td>2.721</td>
<td>2.70</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Specifically, 27 bilingual learners received a MA mean score of 156.22, as opposed to the MA mean score of 154.44 which the 18 monolingual learners achieved (See Table 3.4 above). The P-value was 0.767 >0.05, indicating that there was not a statistically

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Prior studies have indicated that TLS’ existing linguistic experience seems to provide an obvious advantage in regard to their performance in another tonal language (e.g. Deutsch et al., 2004, 2006; Ward, 1999). Future research may expand the TLS sample size to provide a statistically significant research outcome.
significant difference in the MA test scores between the 27 bilingual learners and the 18 monolingual learners. In addition, the 27 bilingual learners received a MLT mean score of 58.67, as opposed to the MLT mean score of 49.06 which the 18 monolingual learners achieved (See Table 3.4). The P-value was 0.013 <0.05, indicating that there was a statistically significant difference in MLT scores between the 27 bilingual learners and the 18 monolingual learners. Finally, the 27 bilingual learners received a MST mean score of 66.96 as opposed to the MST mean score of 54.67 which the 18 monolingual learners achieved (See Table 3.4). The P-value was 0.010 <0.05, indicating that there was a statistically significant difference in the MST scores between the 27 bilingual learners and the 18 monolingual learners. Overall, the 27 bilingual learners who spoke various additional languages performed significantly better than did the 18 monolingual learners on both the MLT and MST, although the MA performance of the two groups did not exhibit a statistically significant difference. In other words, the 27 bilingual speakers had a high degree of familiarity with a second language, and that collectively they did display a statistically significant advantage over their monolingual counterparts. These results indicate the advantage of an additional language in learners’ tonal perception and production. In other words, NNS’ bilingualism plays a role in their perception and production of Mandarin lexical tones.

3.2.5. Summary of the early stage test findings

The preceding sections presented and analysed the central research findings from the early stage testing. It was stated that Key Findings #1 and #2 jointly respond to RQs #1 and #2. It was found that on the one hand, learners’ innate MA was significantly interwoven with their ME, which assisted in refining the definition of MA as one
which combines both the innate nature of MA and the external years of ME (i.e. learned/trained MA). On the other hand, these two findings overall demonstrated a significant, moderate/medium correlation between learners’ innate MA and their tonal perception, between their innate MA and their tonal production, as well as between learners’ learned/trained MA (i.e. ME) and their tonal perception. However, the correlation between their learned/trained MA and their tonal production appeared to be weak/small, which was not statistically significant. Due to the strong support of prior studies (See section 1.5.5 in the Introduction Chapter), this last finding does not necessarily mean ME was not associated with tonal production, but could be accounted for by the small sample size of students with vocal ME. Future research may expand the sample size to further evaluate the correlation between learners’ ME and their tonal production.

Key Findings #1 and #2 overall could suggest that learners’ innate MA and different levels of ME (i.e. learned/trained MA) were intricately interwoven in terms of affecting their tonal perception and production. The interwoven relationship between learners’ innate MA and ME further assisted in refining the definition of MA. Furthermore, to respond to RQ #3, the MA Pitch subtest was found to have the strongest correlation with the MLT, and the Melody subtest had the largest correlation with the MST, both of which were statistically significant. These findings show that pitch height plays an important role in the perception of tones by NNS and that pitch contour plays a crucial role in the production of tones by NNS (Gandour, 1983; Shen & Lin, 1990; Wang et al., 2003). In other words, pitch in MA provides the greatest advantage to learners’ tonal perception, and melody in MA provides the greatest advantage to learners’ tonal production. To answer RQ #4, in addition to MA, learners’ LE in the form of bilingualism seemed to play a role in tonal perception and
production. As a whole, the aforementioned four key findings reveal that MA defined as a combination of innate MA and learned/trained MA (i.e. ME) did help NNS in their perception and production of Mandarin lexical tones during the early stage testing, where in particular, the pitch aspect of MA provided the greatest advantage to learners’ tonal perception, and the melody aspect of MA provided the greatest advantage to their tonal production. In addition to MA, learners’ LE in the form of bilingualism was found to play a role in their tonal perception and production.

In order to further investigate whether the observed impact of MA was sustained over an extended period of time, a longitudinal study was carried out. Hence, the following section will initially introduce the later stage testing, and subsequently the corresponding findings which respond to the final RQ #5 will be provided. Finally, a summary of the later stage testing and a summary of the entire set of findings from the results of both the early and later stage tests will be presented.

The Later Stage Testing

3.3. Introduction

By the thirteenth week of the 2012 semester one at the University of Auckland, the eleven learners who continued to participate in the later stage testing were repeatedly assessed using the MA test, the MLT and the MST. The eleven participants are a mix of monolingual speakers and bilingual speaker: 5 MS and 6 BS\textsuperscript{12}. As a result, the learners’ performance on the MA test, MLT and MST revealed major changes. Learners performed significantly better on the MLT and MST than they did in the

\textsuperscript{12} The 5 MS and 6 BS were compared and contrasted on the MLT and MST. The statistical analysis showed mixed results, which was not statistically significant. Hence, the small sample size was unable to determine whether or not the BS performed significantly better than the MS at this later stage of testing. Future research should expand the sample size of BS and MS.
early stage testing, although their performance on the MA test did not reveal a statistically significant difference. Subsequently, the observed moderate/medium impact of MA in the early stage testing had diminished at the later stage testing, which suggests that the observed effect of MA was not sustained in learners’ tonal perception and production over time. The specific research findings from the later stage testing are presented below.

3.3.1. Key Finding 5#: Did learners’ overall performance improve?

(Together with Key Finding #6, responding to RQ #5)

Table 3.5 Early stage testing vs. Later stage testing

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>N</th>
<th>SD</th>
<th>Std. Error Mean</th>
<th>T-value</th>
<th>df</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA (1st)</td>
<td>155.09</td>
<td>11</td>
<td>20.642</td>
<td>6.224</td>
<td>-.485</td>
<td>10</td>
<td>.683</td>
</tr>
<tr>
<td>MA (2nd)</td>
<td>157.27</td>
<td>11</td>
<td>20.020</td>
<td>6.036</td>
<td>-3.373</td>
<td>10</td>
<td>.007</td>
</tr>
<tr>
<td>MLT (1st)</td>
<td>52.09</td>
<td>11</td>
<td>8.860</td>
<td>2.671</td>
<td>-3.421</td>
<td>10</td>
<td>.007</td>
</tr>
<tr>
<td>MLT (2nd)</td>
<td>60.18</td>
<td>11</td>
<td>12.408</td>
<td>3.741</td>
<td>-3.373</td>
<td>10</td>
<td>.007</td>
</tr>
<tr>
<td>MST (1st)</td>
<td>58.09</td>
<td>11</td>
<td>15.559</td>
<td>4.691</td>
<td>-3.421</td>
<td>10</td>
<td>.007</td>
</tr>
<tr>
<td>MST (2nd)</td>
<td>64.64</td>
<td>11</td>
<td>14.151</td>
<td>4.267</td>
<td>-3.373</td>
<td>10</td>
<td>.007</td>
</tr>
</tbody>
</table>

3.3.1.1. MA 1st (i.e. early stage testing) vs. MA 2nd (i.e. later stage testing)

After one semester (i.e. 60 classroom hours = 5 classroom hours per week* over 12 weeks; tonal training took place in the formal teaching classroom; the training conditions were both communicative and instructional, focusing on both form and meaning) of Mandarin learning, the eleven participants who continued to participate in the later stage testing were re-assessed on the MA test. Subsequently, paired T-tests were carried out to compare and contrast the eleven learners’ MA test performance during both stages. The outcome was that the eleven learners performed slightly
better in the later stage testing than they did in early stage testing, which however is not statistically significant.

Specifically, the eleven learners received an innate MA mean score of 157.27 in the later stage testing, as opposed to the MA mean score of 155.09 which they achieved in the early stage testing (See Table 3.5 above). The mean difference was 2.18, and the P-value was 0.683 >0.05, t (10)=−0.485, \( \eta^2=0.02 \), indicating that there was no significant increase in the innate MA test scores from the early stage testing (M=155.09, SD=20.64, N=11) to the later stage testing (M=157.27, SD=20.02, N=11). Based on Cohen’s conventions (1988) the effect size of \( \eta^2=0.02 \) was small. It can be concluded that the learners’ MA test scores when compared to the scores they received in the early stage testing did not significantly improve in the later stage testing.

3.3.1.2. MLT 1st vs. MLT 2nd

After one semester (i.e. 60 in-class hours =5 hour class time per week\(^*\) over 12 weeks) of Mandarin learning, the eleven participants who continued to participate in the later stage testing were re-assessed on the MLT. Subsequently, paired T-tests were carried out to compare and contrast the eleven learners’ MLT performance at both stages. It was found that the eleven learners performed significantly better in the later stage testing than they did in the early stage testing.

Specifically, the eleven learners received a MLT mean score of 60.18 in the later stage testing, as opposed to the MLT mean score of 52.09 which they achieved in the early stage testing (See Table 3.5). The mean difference was 8.09, and the P-value was 0.007 <0.05, t (10)=−3.37, \( \eta^2=0.53 \), indicating that there was a significant increase in the MLT test scores from the early stage testing (M=52.09, SD=8.86, N=11) to the later stage testing (M=60.18, SD=12.41, N=11). Based on Cohen’s conventions (1988)
the effect size of $\eta^2=0.53$ was large. It can be concluded that the learners’ MLT scores did significantly improve at the later stage testing when compared to the scores they received in the early stage testing. This finding implies that the increase in the learners’ tonal experience of Mandarin lexical tones may have led to the obvious improvement in their MLT performance in the later stage testing.

### 3.3.1.3. MST 1st vs. MST 2nd

After one semester (i.e. 60 classroom hours = 5 classroom hours per week* over 12 weeks) of Mandarin learning, the eleven participants who continued to participate in the later stage testing were re-assessed on the MST. Subsequently, paired T-tests were carried out to compare and contrast the eleven learners’ MST performances in both stages. It was found that the eleven learners performed significantly better in the later stage testing than they did in the early stage testing. Specifically, the eleven learners received a MST mean score of 64.64 in the later stage testing, as opposed to the MST mean score of 58.09 which they received in the early stage testing (See Table 3.5). The mean difference was 6.55, and the P-value was 0.007 <0.05, $t(10)=-3.42, \eta^2=0.57$, indicating that there was a significant increase in the MST test scores from the early stage testing ($M=58.09, SD=15.56, N=11$) to the later stage testing ($M=64.64, SD=14.15, N=11$). Based on Cohen’s conventions (1992) the effect size of $\eta^2=0.57$ was large. It can be concluded that the learners’ difference in MLT performance between both stages was statistically significant. This finding implies that the increase in the learners’ tonal experience of Mandarin lexical tones may have similarly led to the obvious improvement in their MST performance in the later stage testing.

As a whole, the three assessments were repeated to evaluate the eleven participants’ performance on the MA test, the MLT and the MST in the later stage testing. The
outcome revealed that the learners improved significantly on the MLT and on the MST, but did not improve significantly on the MA test. These findings suggest that the learners’ tonal learning experience over one full semester may have significantly enhanced their MLT and MST, although their MA test performances remained similar. In order to further explore whether their MA had a continuously significant correlation with their MLT and MST in the later stage testing, another bivariate correlation was conducted, as presented below.

3.3.2. Key Finding #6: Bivariate Correlations between the MA, MLT and MST

(Together with Key Finding #5, responding to RQ #5)

The MA test scores were correlated to the MLT scores and MST scores respectively in the longitudinal study, which aimed to further discover if the moderate/medium correlation between learners’ innate MA and their tonal perception, as well as tonal production, remained in the later stage testing. Intriguingly, unlike the significant positive moderate correlation found in the early stage testing, the findings in the later stage testing did not indicate a significant correlation between the learners’ innate MA and their MLT or MST results. At the same time, the MLT results consistently demonstrated a significantly strong positive correlation with MST at the later stage testing. As the last finding was a by-product of the correlation analysis between MA and MLT, as well as between MA and MST, it is not the focus in this study and therefore will not be further discussed here but will be briefly addressed in the Discussion chapter.
The association between the eleven learners’ MA test performance and their MLT results was not continuously statistically significant. Specifically, the correlation coefficient \( r \) between the learners’ MA test and their MLT was 0.301 and the P-value was 0.369 > 0.05, which is not statistically significant (See Table 3.6 above). This result suggests that MA was less likely to have continuously played a role in the learners’ MLT in the later stage testing. In addition, the association between the learners’ MA test performance and their MST similarly showed non-statistical significance. Specifically, the correlation coefficient \( r \) between the learners’ MA and their MLT was 0.410 and the P-value was 0.210 > 0.05, which is not statistically significant (See Table 3.6). This finding indicates that MA tended not to have consistently played a part in the learners’ MST in the later stage testing. Finally, the association between the learners’ MLT and MST consistently revealed a strong/large level of association. Specifically, the correlation coefficient between the learners’
MLT and their MST was 0.891 and the P-value was .000, which is statistically significant at the 0.01 level (See Table 3.6). Thus, the higher the learners’ MLT scores, the better they performed on the MST. This result suggests a positive large association exists between the learners’ MLT and MST performances. The two variables correlated to r 0.891, and the significance was p<0.01 which, when squared, becomes R²=0.7938 or 79.4 per cent, and therefore similarly indicates a positive strong effect. Hence, the MLT can explain 79.4 per cent of the variance in the MST scores, which similarly implies that MLT performance could be the determining factor in the variance in MST performance in the later stage testing.

3.3.3. Summary of the later stage testing

The above sections have specified the key findings resulting from the later stage testing. After one semester of tonal learning experience, the eleven learners who continued to participate in the later stage testing were re-assessed on the MA test, the MLT and the MST. It was found that the learners had made significant improvements on the MLT and MST in the later stage testing, which suggests that the increase in tonal experience may have enhanced their tonal performance in perceiving and producing the target lexical tones. The learners’ MA test scores in the later stage testing appeared to be similar to those from the early stage testing, where learners’ MA did not notably change as their tonal experience increased. This result supports the innate aspect of the MA test used in this (See section 2.4.2.2 in Methodology Chapter). In other words, innate MA does not vary with a change in the external environment. Subsequently, Spearman’s bivariate correlations were conducted to re-evaluate the relationship between the MA test and the MLT, as well as the MST. As expected, it was found that MA no longer had a significant correlation with MLT and
MST, which suggests that MA played a lesser role in the learners’ MLT and MST in the later stage testing, compared to its significant moderate correlation with the MLT and MST in the early stage testing. The findings from the longitudinal study (i.e. early stage testing and later stage testing) increasingly revealed the different effects of MA in perceiving and producing Mandarin lexical tones by NNS of Chinese. In short, the impact of observed MA on learners’ tonal perception and production had become lesser over time, which implies that MA may help L2 learners in their perception and production of Mandarin lexical tones at the early stage of their learning, but may not necessarily be important at the later stage of learning.

3.4. Summary of the chapter

This chapter has demonstrated six key findings from both the early stage and later stage testing. In the early stage testing, the relationship between the learners’ innate MA and their tonal perception, between their innate MA and their production, as well as learners’ learned/trained MA and their tonal perception, was found to be positive moderate/medium, which was statistically significant. Due to the small sample size, however, learners’ learned/trained MA and their tonal production did not seem to correlate with each other. Concurrently, innate MA was found to be intricately related with ME. The research outcome overall suggest that MA defined as a combination of innate MA and ME did play a significant role in perceiving and producing Mandarin lexical tones at that particular stage. In addition, among the four MA subtests, the pitch aspect of MA showed the most impact on tonal perception, and the melody aspect of MA presented the most impact on tonal production, both of which were statistically significant. These findings elaborate which particular aspect of MA provides the most advantage in learners’ tonal perception and production respectively.
These results also reveal the different foci among the four Mandarin acoustic cues that learners tended to direct attention to in the process of perceiving and producing target lexical tones. Apart from the MA effect observed in the early stage, learners’ LE in the form of bilingualism has affected their tonal perception and production. In the later stage testing, MA did not continuously show a statistically significant correlation with tonal perception and production, but learners’ MLT and MST performances had significantly improved after one semester of tonal learning experience. These results suggest that MA had a lesser impact on learners’ tonal perception and production in the later stage testing. Instead, the increase in the learners’ tonal experience over the duration of one semester played an influential role in their tonal perception and production.

Overall, as learners’ tonal experience increased, the significantly positive moderate correlation observed in the early stage testing between MA and both MLT and MST was observed to diminish, however learners’ tonal learning experience appeared to play a crucial role in determining their success in tonal perception and production. In short, learners’ MA did have a positive impact on learners’ perception and production of Mandarin lexical tones at the initial stage of Mandarin tone learning, but this observed effect of MA was not sustained after one-semester of the learners’ tonal learning experience. In the next chapter, the Discussion Chapter, the six key findings of this study will be discussed in the context of their significance to prior studies.
Chapter 4: Discussion

4.1. Overview of the chapter
This thesis has investigated whether MA helps second language learners in their perception and production of Mandarin lexical tones. Specifically examined was whether there was a significant correlation between learners’ MA defined as a combination of innate MA and learned/trained MA and their tonal perception, as well as between MA and their tonal production. The next section of this chapter provides a brief account of the study so far, followed by a summary of the results of both stages of testing. The third section deals with the findings of the early stage testing. It links each of the key findings of this stage to the research sub-questions, explains the findings and seeks to account for them. This part also makes reference to relevant studies, discusses the degree to which they agree with or diverge from the current study and evaluates the significance of the current findings. The fourth section deals with the later stage test findings and follows the same process as outlined above for section three. The final section, section five, integrates both stages of the test results, discusses the broader issues they raise, and relates them to the main research question and the five research sub-questions:

Main research question:
Does musical aptitude help non-native speakers of Chinese in their perception and production of Mandarin lexical tones at different stages of their learning?

Research sub-questions:
RQ #1: How should musical aptitude (MA) be defined?

RQ #2: Is there a significant correlation between non-native speakers (NNS)’ MA and their perception and production of Mandarin tones?
RQ #3: What aspect of MA provides the most advantage in NNS’ tonal perception and tonal production respectively?

RQ #4: Are there other factors in addition to MA that play a role in NNS’ Mandarin tonal perception and production?

RQ #5: If MA is a factor in Mandarin tone perception and production, does its impact change over time?

4.2. Background to the study

The overall aim of this study is to investigate the role of MA in Mandarin learners’ tonal perception and production. One main research question and five research sub-questions were formulated to achieve this purpose, where the overall findings in regard to the five sub-research questions serve to respond to the main research question.

The research was divided into two stages: early stage testing and a later stage testing. The first two research questions address what contributes to an appropriate definition of MA, and the degree of correlation between learners’ MA and their lexical tonal perception, as well as between MA and their tonal production, which corresponds to the Key Findings #1 and #2. To answer the first two research questions, SPSS Spearman bivariate correlations were analytically conducted between the innate MA test scores and the MLT scores, as well as between the innate MA test scores and the MST scores. Subsequently, SPSS Spearman nominal correlations were analytically conducted between learners’ different levels of ME (i.e. learned/trained MA) and their innate MA scores, MLT and MST. The complex inter-relationship between the learners’ innate MA and their ME which was learned/trained MA aided in defining MA in this study. A significant correlation between learners’ MA (i.e. innate MA +
ME) and their tonal perception, as well as between their innate MA and their tonal production, was observed, but an insignificant, weak/small correlation between learners’ ME and tonal production emerged in the early stage testing. In response to Research Question #3, SPSS Spearman bivariate correlations were carried out to compare each of the MA subtests and MLT, as well as each MA subtest and MST, each of which corresponds to Key Finding #3. In particular, among the four MA subtests, the pitch aspect of MA was shown to have the most impact on MLT, and the melody aspect of MA exhibited the most impact on MST, which were both statistically significant. In other words, the pitch height of MA provides the greatest advantage in NNS’ tonal perception, and the pitch contour/melody of MA provides the greatest advantage in their tonal production. Responding to Research Question #4, Key Finding #4 revealed that there were other factors in addition to MA that may play a role in NNS’ Mandarin tonal perception and production. To assess these other factors, SPSS Independent T-test analyses were carried out to compare monolingual speakers with bilingual speakers. The results indicated that in addition to MA, learners’ LE in the form of bilingualism seemed to play an influential role in NNS’ tonal perception and production. Specifically, the bilingual learners seemed to have a greater advantage in tonal perception and production than the monolingual learners.

In order to answer Research Question #5 in the later stage testing, Key Findings #5 and #6 were analysed. Paired T-tests were carried out to compare and contrast learners’ early stage performance on the MA test, and MLT and MST with their performance during the later stage testing. The results correspond to Key Finding #5. Subsequently, in Key Finding #6, SPSS Spearman bivariate correlations were conducted once again in order to evaluate whether the statistically significant positive moderate/medium correlation in the early testing was sustained between learners’ MA
and their MLT, as well as between MA and MST. The results overall indicated that the learners’ MA did not continuously reveal a statistically significant correlation with the MLT and MST results, but the learners’ MLT and MST performances had significantly improved after one semester of tonal learning experience. All these circumstances combine to create a somewhat complex picture of the effect of MA in perceiving and producing Mandarin tones by NNS of Chinese. This complexity reflects the dynamic, changing role of MA in learners’ tonal perception and production over an extended period of time, an insight which makes a contribution to the overall response to the main research question.

4.3. Early stage test findings

4.3.1. Background

This section addresses the findings of the study relating to Research sub-Questions (RQ) #1, #2, #3 and #4, and discusses in sequential order the four Key Findings #1, #2, #3 and #4, produced by SPSS Spearman bivariate correlations, Spearman nominal correlations, and Independent T-tests analysis.

4.3.2. Discussion of Key Findings #1 and #2

(Jointly responding to RQs #1 and #2)

Key Findings #1 and #2 are a response to RQs #1 and #2. The complex inter-relationship, between learners’ innate MA and their ME, which was learned/trained MA, was observed from both Key Findings #1 and #2. This complex inter-relationship helped to provide an appropriate definition of MA, which answers RQ #1. In addition, in Key Findings #1 and #2, a significant correlation was found between learners’ MA which combines innate MA and learned/trained MA and their tonal perception, as well as between their innate MA and tonal production. But there was an insignificant weak/small correlation between their learned/trained MA and tonal
production. This evidence responds to RQ #2. The following sub-section discusses Key Finding #1 first, followed by the discussion of Key Finding #2. Finally, an overall discussion of the responses to RQs #1 and #2 is provided.

4.3.2.1. Discussion of Key Finding #1

In the early stage testing, the innate MA test scores were correlated with MLT scores and MST scores respectively. The relationship between the learners’ innate MA and their tonal perception, as well as tonal production, was found to be positive moderate/medium, which was statistically significant. Specifically, the association between the learners’ innate MA test performance and their MLT was assessed to be at the moderate/medium level. Similarly, the association between the learners’ innate MA test performance and their MST was assessed to be at the moderate/medium level. It seems that higher levels of innate MA are associated with better performance in learners’ MLT and MST. The outcome indicates that MA did play a role in perceiving and producing Mandarin lexical tones at the time of the early stage testing. Simultaneously, the association between the learners’ MLT and MST was, as expected, found to be positive strong/large. The higher the learners’ MLT scores, the better they performed on the MST, which is supported by prior studies that tonal production performance is dependent on accurate perception and vice versa (e.g. Wang et al., 2003). Since this finding is not the focus, but a by-product in the current study, it will not be discussed further here.

The significant finding of a positive moderate/medium correlation between learners’ innate MA and MLT, as well as between innate MA and MST, indicates that a relationship between innate MA and tonal perception, as well as with tonal production, does exist, and that the strength of the relationship is also positive moderate/medium. These findings help to provide more conclusive evidence for the inconsistent results
in previous studies discussed in section 1.5 of Introduction Chapter where some investigators found little or no relationship between musical aptitude and second language learning of tone (e.g. Peoppel, 2001; Anvari et al., 2002), whereas others found such a relationship to exist (e.g. Slev & Miyake, 2006; Wong et al., 2007). The current study considered the link between innate MA and Mandarin tonal ability more rigorously and precisely than what had been done in the previous research, and the aforementioned findings of the current study support the general claims made by previous studies (e.g. Kuhl et al., 1992; Deutsch et al., 2004; 2006; Wee, 2008) that music (aptitude) and language in general, and specifically music (aptitude) and tonal languages, as well as musical aptitude and Mandarin Chinese tone, do have an association (See section 1.5 in the Introduction Chapter). However, it needs to be mentioned that the specific focus and research instruments used in these previous studies were different from those in the current study.

Specifically, the findings were supported by behavioural and neuro-scientific studies discussed in section 1.5 of the Introduction Chapter (e.g. Zatorre et al., 2002; Slev & Miyake, 2006; Wong et al., 2007; Chandrasekaran et al., 2009; Jäncke, 2009; Bidelman et al., 2010; Asaridou & McQueen, 2013; Hutka et al., 2013; 2015) that speech and music share mechanisms or similar networks in the brain for sound category learning. The complex relationship between music and language were indicated by these cited studies. At the behavioural level, prior studies (e.g. Brutten et al., 1985; Slevc & Miyake, 2006; Milovanov et al., 2009; Milovanov and Tervaniemi, 2011) highlighted musical aptitude correlates uniquely with L1 and L2 phonological perception and production in adults, as well as in children. Furthermore, the findings of the current study are also supported by previous research discussed in section 1.5 of the Introduction Chapter (e.g. Burnham et al., 2015; Liu et al., 2015) that people
with amusia are impaired in linguistic tasks. In addition to the above studies on music (aptitude) and language in general, other studies discussed in section 1.5 of the Introduction Chapter (e.g. Gordon, 1989; Cooper & Wang, 2010; Delogu et al., 2009; Hutka et al., 2015) have also identified the connection between musical and tonal language. These cited studies similarly suggest that musical aptitude played a role in the context of their research, which supports the findings of the present study. Finally, some studies discussed in section 1.5 of the Introduction Chapter (e.g. Delogu et al., 2006; 2009; Jiang et al., 2010; Wang et. al., 2012) particularly explored the relationship between musical ability and Mandarin Chinese tone, the results of which support the findings of the current study, that is, there is a significant correlation between learners’ MA and their tonal perception, as well as tonal production.

Overall, the studies cited above are generally in agreement that music (aptitude) and language in general, and music (aptitude) and tonal language, as well as music aptitude and Mandarin tone in specific, do have a connection. This perspective supports the findings of the current study. However, the current study diverges from the previous studies in a number of ways. Specifically, most of the previous studies (e.g. Zatorre et al., 2002; Hutka et al., 2013; 2015) were neuro-scientific and psychophysiological, and focused on trained musical ability rather than on innate musical aptitude/talent/genetics. In other words, few of them precisely defined musical aptitude so as to be able to select the most appropriate musical aptitude test for their particular research aims (e.g. the innate or learned/trained aspect of MA was not clearly indicated, and accordingly the selected MA test was not compatible with the so-called MA in their research contexts). Lack of clarity in regard to the definition of MA was a main issue in prior studies. No research has yet applied a musical aptitude test corresponding to the primary key acoustic cues of Mandarin lexical tone,
including pitch height, pitch contour, loudness and duration. In addition, other variables in the previous studies were not well controlled. These include the specific target language being investigated (i.e. most previous studies focused on the Language in general, or Cantonese tone in particular, but the current study focused on Mandarin lexical tones), and the aspects of music aptitude and language skills being investigated (i.e. some studies focused on only partial aspects of musical aptitude such as melody or timbre). In addition, whether language perception or production was being assessed in each of the previous studies was not clearly stated. This is important, as both are two separate dimensions of acquiring a foreign language. The other variables which were not well controlled in the studies cited were the lexical or syntactical structures of tones (i.e. some studies focused on tones in syntactic structure), and the language background of the participants. In regard to this last variable, most of the previous studies (e.g. Delogu et al., 2006; 2009; 2010; Jiang et al., 2010) compared the NS of Mandarin Chinese to English speakers; few studies compared NNS monolingual English speakers to bilingual speakers who speak diverse additional languages.

It is evident that the use of different criteria and inconsistent measures of audio-lingual skills may not only contribute to the inconsistent research results mentioned earlier, but might also explain how the current study diverges from the previous studies. In short, previous studies that have investigated the relationship between learners’ innate musical aptitude and their Mandarin lexical tonal perception, as well as tonal production, are scarce. In addition, no previous studies have clarified the precise strength (i.e. small/weak, medium/moderate, large/strong) of the relationship between music (aptitude) and language in general, and innate MA and Mandarin learners’ lexical tonal perception, as well as tonal production, in particular. In these
regards, the current study, relative to the prior studies, has provided a more precise research design and a more precise strength of the correlation between Mandarin learners’ innate MA and their tonal perception, as well as between innate MA and their tonal production. The strength of the correlation was found to be positive moderate/medium. Therefore, the findings of the current study are noteworthy due to the scarcity and imprecision of previous research undertakings in this field.

On the other hand, in this study, the positive moderate/medium correlation between learners’ innate MA and MLT, as well as between MA and MST, implies that there are other factors affecting the learners’ MLT and MST performance. These include learning styles, learning intensities, learning strategies, learners’ age, gender, and foreign language assessment anxieties. These factors or variables were uncontrollable and were not the focuses in this study and will not be discussed here. However, another key factor, which was learners’ different levels of ME, was found to play a role in learners’ tonal perception and production, and to be intertwined with their innate MA. The following sub-section discusses how learners’ ME (i.e. learned/trained MA) plays a role in learners’ perception and production of Mandarin lexical tones, and how this ME in combination with innate MA aided in answering RQs #1 and #2.

4.3.2.2. Discussion of Key Finding #2

ME, which is learned/trained MA, had a strongly significant moderate/medium correlation with learners’ innate MA, and a significant moderate/medium correlation with tonal perception, but had an insignificant weak/small correlation with tonal production. Prior studies discussed in section 1.5.5 of the Introduction Chapter (e.g. Besson et al., 2007; Chandrasekarn et al., 2009; Jäncke, 2009; Asaridou & McQueen,
2013; Burnham et al., 2014; Kang & Williamson, 2014) declare that there is a close link between musical experience/training and L2/foreign language learning. The musical experience or training modulates speech processing, largely on pitch processing. Similarly, musical practice or training was found to have a positive effect on learners’ language learning in general, and Mandarin tone learning in particular. It is evident, therefore, that the studies cited above provide robust evidence that musical experience enhances auditory acuity, which can aid in speech acquisition in general, and tonal perception and production in particular. Obviously, the result of the present study with respect to the significant correlation between learners’ ME and their tonal perception is supported by the prior studies, but the result in relation to an insignificant weak/small correlation between ME and tonal production seems unexpectedly contradictory with prior studies. This contradiction, however, does not mean learners’ ME was not associated with their tonal production, but could be explained by the small sample size of each of the three ME groups.

In addition, it was also found that there were only two participants who received formal vocal ME. They performed better on MST than did students who received formal instrumental ME only, and interestingly the latter students performed better on the MLT than did the former students. These differences may imply that vocal ME may correlate with Mandarin tonal production, and instrumental ME may correlate with Mandarin tonal perception. The fact that the sample size of students with instrumental ME was much larger than these with vocal ME may account for the mixed research results that ME was significantly correlated with tonal perception, but not necessarily with tonal production. Although the sample size was unfortunately small in each of the three ME groups, the results are noteworthy, which suggests that future studies expand the sample size of each of the ME groups and students with
vocal ME. Overall, a complex relationship emerges between innate MA, ME, tonal perception and tonal production, in that learners’ tonal perception and production may be partially influenced by innate MA and partially by ME, which is learned/trained MA. These findings also indicate the difficulty of teasing apart learned/trained MA and innate MA.

Apart from the above, the current study also diverges from prior studies in the specific aspects of language being investigated, that is, the studies cited above focused on the word or sentence learning of L2 or foreign language, but the current study concentrated on the Mandarin lexical tones in monosyllables and disyllables.

4.3.2.3. Overall discussion of response to RQs #1 and #2

Discussions of Key Findings #1 and 2# reveal that learners’ tonal perception and production were partially influenced by the innate nature of MA, and partially influenced by their external nurtured ME which was learned/trained MA, which in turn displays a complex relationship between innate MA and ME. This complexity suggests that MA and ME were interwoven in affecting learners’ tonal perception and production, which contributes to an appropriate definition of musical aptitude as a combination of innate MA and ME (i.e. learned/trained MA). It is this complexity which prevents previous studies from being able to clearly differentiate innate MA from ME, and it might also explain why the previous studies did not clearly clarify the definition of MA/musical talent/musical ability/musicality so as to be able to apply the corresponding MA test. Due to the vague definition to and inappropriate selection of MA test in the prior studies indicated in section 1.5.1 of Introduction Chapter (e.g. Sleve & Miyake, 2006; Delogue et al., 2009; Cooper & Wang; 2010; Wang et. al., 2012), their research reliability and validity were problematic. Specifically, these cited studies appear to focus on learned or trained musical ability instead of the innate
nature/genetics of musical aptitude, but they do not explicitly define that they are doing so. This lack of clarity leads to ambiguity about the concept of musical aptitude. It is evident that the lack of clarity in regard to the definition of MA resulted in an inappropriate selection of MA tests, thus affecting the reliability and validity of the research undertakings. The inappropriate use of MA tests in previous studies may partially explain the inconsistent research findings in relation to the association between learners’ MA and their tonal perception, as well as their tonal production.

However, an attempt has been made in this study to fill these gaps by robustly defining MA as a combination of innate MA and ME, which in turn allowed for the selection of the most appropriate MA test. On the other hand, Key Findings #1 and #2 jointly highlight and clarify the precise strength of the correlation between learners’ MA (i.e. innate MA and ME) and their tonal perception, as well as tonal production, where the strength is significantly moderate/medium, except for the insignificant weak/small correlation between ME and tonal production. This highlighting and clarification was not achieved in previous studies (e.g. Patel, 2008; Chandrasekarn et al., 2009; Jäncke, 2009; Burnham et al., 2015). The explanation for the last insignificant result of the weak/small correlation between ME and tonal production is discussed in section 4.3.2.2.

4.3.3. Discussion of Key Finding #3 (Responding to RQ #3)

To examine RQ 3# in regard to which MA subtest had the most advantage on learners’ tonal perception and production respectively, each of the four subtests was bivariate-correlated with the MLT and MST respectively. Among the MA four subtests, the Pitch subtest for pitch height showed the strongest correlation with MLT for tonal perception, and the Melody subtest for pitch contour presented the strongest correlation with MST for tonal production, which were both statistically significant.
These findings assisted in specifying which particular aspect of MA had the largest
correlation with the MLT and the MST respectively. This result revealed the different
foci among the four Mandarin acoustic cues that learners tended to direct their
attention to in the process of perceiving and producing target lexical tones. In order to
listen/perceive the target Mandarin lexical tones, the participants in this study, who
were NNS of Mandarin, directed their attention more to pitch height and less to the
pitch contour dimension (i.e. Melody subtest). NNS participants in this study paid
more attention to the melodic pitch contour and less to the pitch height (i.e. Pitch
subtest) when speaking/producing the target Mandarin lexical tones. Overall, it seems
that NNS learners of Mandarin lexical tones encountered more difficulty in perceiving
the melodic pitch contour and accordingly had less difficulty in perceiving pitch
height, whereas they appeared to have more difficulty in producing pitch height and
less difficulty in producing a pitch contour. This implies that pitch height plays an
important role in the perception by NNS of lexical tones, and that melodic pitch
contour plays a crucial part in the production of tones by NNS.

These results are consistent with those of prior studies which found that NNS
perception appears to be determined by pitch height, whereas their production tends to
be determined by the contour of the tones (e.g. Gandour, 1983; Shen & Lin, 1990;
Wang et al., 2003; Young, 2010). In contrast, native Mandarin listeners attach slightly
more importance to pitch contour than pitch height for perception (Gandour, 1983;
1984; Wang et al., 2003), and native speakers utilise both the contour and
height/register to determine tonal categories (e.g. Wang et al., 2003; Bent, 2005;
Yang, 2010). However, the current study diverges from these prior studies in two
ways: first, NNS in previous studies were either only English native speakers or only
German native speakers, but the NNS in the current study came from different
language backgrounds, including native speakers of English, Korean, Vietnamese, Bahasa Malaysia and Cambodian. Regardless of their different language backgrounds, NNS generally pay attention to different acoustic cues for tone than do NS; second, no study so far has specifically investigated the other acoustic cues of Mandarin lexical tones, such as amplitude, or duration. The current study, however, attempted to consider all of the four phonetic cues of Mandarin lexical tones so as to be compatible with the MA test, for the purpose of discovering which aspect(s) of MA had the most impact on learners’ tonal perception and production respectively.

Furthermore, what needs to be addressed here is that these results were drawn from monosyllables and disyllables in isolation, which implies that pitch height and pitch contour are the most important or primary acoustic cues for Mandarin monosyllables and disyllables. However, other acoustic cues such as loudness/amplitude and time/duration could start to play equally important roles when the target Mandarin syllables are embedded in larger syntactic structures/connected speech, by tone sandhi rules, intonation, stress, monolinguals/bilinguals, gender, age, geography, and speaker’s mood (Dow, 1972; Yip, 2002; Sanders, 2008). In real life speech, the four tones of Mandarin are realized with variations in their acoustic properties, according to the above factors. Some studies (e.g. Lin, 1985; Sun, 1998; Duanmu, 2007) show that when lexical tones are produced in isolation, their contours seem well defined and quite stable; when produced in context, however, the tonal contours, amplitude and duration undergo certain variations depending on the preceding and following tones. Other studies (e.g. Broselow et al., 1987; Lin, 1985; Shen, 1989) explored the perception of tones presented in different syntactical structures, where the carry-over effects and anticipatory effects were addressed to highlight the importance of duration and amplitude in the connected speech. Duration is also important to distinguish T2
and T3 (Deng & Dang, 2007). Overall, it is not difficult to see the complexities of how each phonetic cue of Mandarin tones plays an individual role in the form of isolation/citation, disyllable structures and syntactic structures. Therefore, Key Finding #3 was drawn from the monosyllables and disyllable tones only, which should not be generalized to the wider contexts such as the aforementioned connected speech or syntactical structures. In order to evaluate how NNS and NS perceive and produce the target tones differently future research should pay particular attention to Mandarin tones in syntactic structures and connected speech.

4.3.4 Discussion of Key Finding #4 (Responding to RQ #4)

Learners’ language experience in the form of bilingualism in addition to MA seemed to play a role in learners’ tonal perception and production. Learners’ LE in the form of bilingualism was analysed by comparing and contrasting 27 BS with 18 MS\(^{13}\). The results indicated that bilingual speakers all performed significantly better than did monolingual speakers in tonal perception and production, although their performance on the MA test was not significantly different. This result suggests that speaking an additional language may be advantageous to Mandarin lexical tone learners because it might enable them to achieve a better performance on the MLT and MST. In other words, speaking an additional language may help to enhance learners’ tonal perception and production. This finding is supported by previous studies highlighted in section 1.4.3.1 of the Introduction Chapter (e.g. Bruck & Genesee, 1995; Bialystok, 1999; Bialystok et al., 2003; Marian et al., 2009; Ressel et al., 2012; Asaridou and McQueen, 2013; Krizman et al., 2014; Wang & Saffran, 2014; Yousaf & Khan, 2014) that bilingual experience or bilingualism could have a gradient effect on the

\(^{13}\) A statistical analysis was conducted to determine if 19 Korean speakers, who constituted the largest group of bilingual speakers, had a particular advantage over other bilingual speakers. The result did not indicate such an advantage.
perception and production of another language. However, the current study diverges from previous studies in the sample size of bilingual speakers and monolingual speakers, and also due to the fact that the language skills being targeted were both perception and production of Mandarin lexical tones of monosyllables and disyllables rather than longer utterances. Additionally, the current study diverges from the cited previous studies because the latter focused on early bilingual speakers who were able to speak an additional language before puberty, but the learners in this study were a mix of early bilingual speakers and late bilingual speakers, some of whom learned the additional language before and some after reaching the puberty.

Nonetheless, it is also possible that other variables which could not be controlled for in this study might have impacted on their tonal perception and production. These variables might have been, for example, the differences in learning styles and learning strategies, and a difference in the amount of time and effort that individual learners might have invested in their learning. Future studies may take these variables into account. Although the research context of the current study was different from those of previous research undertakings, the findings are still noteworthy and may play a role in learners’ tonal perception and production, in addition to learners’ MA.

In sum, Key Findings #1, #2, #3 and #4 were observed in the early stage testing, in which Key Findings #1 and #2 were jointly in response to Research sub-questions #1 and #2, Key Finding #3 responded to sub-question #3, and Key Finding #4 answered sub-question #4. The significant moderate/medium correlation observed between leaners’ MA (i.e. a combination of innate MA and learned/trained MA) and their tonal perception, as well as between their innate MA and their tonal production, and the insignificant correlation discovered between ME and tonal production, was discussed
in accordance with the relevant existing literature. An appropriate definition of MA was concurrently shaped based on the joint key findings. Subsequently, the strongest correlations between the pitch aspect of MA and tonal perception, as well as between the melody aspect of MA and tonal production, were discussed in relation to monosyllables and disyllables, as well as how NNS and NS perceive and produce the lexical tones respectively. This discussion was in response to RQ #3. Furthermore, in addition to MA, learners’ LE in the form of bilingualism was discussed in terms of how bilingualism enhances learners’ tonal perception and production. These discussions aid in examining the effect of MA in Mandarin tonal perception and production by NNS of Chinese at the early stage testing. The overall results from the early stage testing indicated that learners’ MA does help their perception and production of Mandarin lexical tones. After an extended period of time (i.e. 60 classroom hours = 5 classroom hours per week* over 12 weeks), whether the impact of MA had changed was examined. The effect of MA on tonal perception and production was re-evaluated in the later stage testing. The following section will discuss Key Findings #4 and #5 from the later stage testing, each of which is in response to the final research sub-question 5.

4.4. Later stage test findings

4.4.1. Background

This section addresses the findings of the study relating to Research Question #5, and discusses the two Key Findings #5 and #6, produced by the SPSS Spearman bivariate correlations, and the Paired T-tests analysis.
4.4.2. Discussion of Key Findings #5 and #6 (Jointly responding to RQs #5)

In 2012, during the course of the thirteenth week of semester one at the University of Auckland, the MA test, MLT and MST were repeated in order to detect any possible changes that may have taken place over the preceding twelve weeks in regard to the participants MA and tonal perception, as well as tonal production. Paired T-tests were undertaken to compare and contrast learners’ early stage testing scores with their later stage testing scores on the MA test, MLT and MST; Spearman’s bivariate correlations were then conducted to re-evaluate the relationship between the MA test and the MLT, as well as the MST. In doing so, the extent of the Mandarin learners’ MA effect on learners’ tonal perception and production could be investigated further.

After one semester of intensive tonal learning experience (i.e. 60 classroom hours = 5 classroom hours per week* over 12 weeks; the training conditions were both communicative and instructional), the eleven learners who continued to participate in the later stage testing were re-assessed on the MA test, the MLT and the MST. It was found that the learners had made significant improvements on the MLT and MST, which suggests that the increased tonal learning experience may have enhanced their tonal performance in perceiving and producing the target lexical tones. The learners’ MA test scores in the later stage testing appeared to be similar with those from the early stage testing, where the learners’ MA did not notably change as their tonal experience increased. This result supports the innate aspect of the MA definition and the innate MA test designed in this study (See section 4.3.2). In other words, innate MA does not vary with a change in the external environment. Subsequently, as expected, it was found that MA no longer had a significant correlation with MLT and MST. This suggests that MA played a lesser role in the learners’ MLT and MST in the later stage testing, compared to its significant/ moderate correlation with the MLT.
and MST in the early stage testing. The findings from the longitudinal study (i.e. early stage testing and later stage testing) increasingly revealed how the effects of MA altered the perception and production of Mandarin lexical tones by NNS of Chinese over an extended period of time.

The above findings are supported by those of previous research (See section 1.5.7 in the Introduction Chapter) that the adult human perceptual system can be modified with auditory training of L2 segmental properties (e.g. Leather, 1987; Wang et al., 2001a; 2003; Wayland et al., 2010) After short perceptual tone training, non-native speakers of Mandarin improved both their perception and production of Mandarin tones. These results overall suggest that tonal learning experience, specifically tonal training, produces highly generalized learning that results in long-term modifications to the learners’ perception and production of Mandarin tones. The long-term modifications to the learners’ perception and production of Mandarin tones may enable learners to associate meaning to lexical tones rather than to listen to lexical tones as pitch differences (Wang, 2003). This transformation would have made the later stage learning more meaningful than the learning at the early stage, a transformation which may ultimately have contributed to the learners’ enhanced tonal perception and production.

The current study diverges from previous research in two ways. First, few studies have conducted longitudinal research to assess the changing effect of MA on learners’ tonal perception and production. The prior studies discussed in section 1.5.6 in the Introduction Chapter did support the close link between music and language, but the studies discussed in section 1.5.8 in the Introduction Chapter did not support this link. This inconsistency in the results of previous studies could have come about because
some studies were conducted at an early learning stage while others were conducted at a late learning stage. None of these studies included a longitudinal component, so it is not possible to compare their findings with one another. Second, most of the studies examined how musical training influenced language performance, rather than how tonal learning experience/training affected tonal performance. The findings of the current study have pedagogical implications for teachers of tonal language in general, and teachers of Mandarin in particular. The findings suggest that after learners have undergone an intensive tonal learning experience the effect of MA diminishes in the perception and production of Mandarin tones. Mastering Mandarin tones does not necessarily require an outstanding innate MA and trained/learned MA, but rather intensive tonal learning experience/training. In other words, learners’ tonal perception and production will only improve if they are actively dedicated to the learning process. This finding can encourage learners to make every effort to learn Mandarin tones, and provides useful insight for teachers to implement in their teaching pedagogy.

It cannot, though, be denied that other variables/factors might have contributed to the learners’ enhanced tonal perception and production in the later stage testing. These include learners’ learning style, learning strategies, learning time and effort invested outside the classroom, learning motivation, ME, age, gender, memory, confidence, self-esteem, teachers’ pedagogy and finally, instruction in class (Thogmartin, 1982; Horwitz et al., 1986; Johnson & Newport, 1989; 1991; Holmes, 2001; Burman, 2008), as well as the incorporation of both known words and unknown words in MLT and MST. In regard to the last variable, we should be aware that if a student correctly identifies the tone of a known vocabulary item, it will remain unclear whether this is because s/he is ‘hearing’ the tone correctly or is simply mentally recalling having
previously seen the correct written tone mark. This discussion of variables should be seen in the context of the small sample size of the present study, particularly in the later stage testing. In order to re-evaluate the correlation between MA and MLT, as well as between MA and MST, and to compare and contrast the performance during both stages of testing, future studies should enlarge the sample size and take these variables into account.

4.5. Discussion of the overall findings

Together, the 6 Key Findings of the early stage testing and later stage testing of this study have responded to the main research question about whether MA helps L2 learners’ perception and production of Mandarin lexical tones. The combination of the findings of the 5 research sub-questions has answered the main research question, and presented a picture of how the effect of learners’ MA defined as a combination of innate MA and learned/trained MA changed their tonal perception and production. This insight allows us to understand the relationship between learners’ MA and tonal perception, as well as the relationship between MA and their tonal production. The findings show that although a significant correlation was observed between learners’ MA and their tonal perception, as well as tonal production, at the early stage testing, this significant correlation did not last into the later stage testing. Although MA was no longer observed to have a significant correlation with learners’ tonal perception and production, learners’ tonal perception and production significantly improved as their tonal learning experience increased. The following key points provide an overview of the discussion, and also provide pointers for possible future research.

1) The close link observed between learners’ MA (i.e. innate MA + learned/trained MA) and their tonal perception, as well as tonal production, does not only aid in
providing more conclusive evidence for the inconsistencies revealed in prior studies, but also helps to elaborate the definition of MA. In terms of theory, the study results contribute to a refinement of existing theories about the link between Mandarin learners’ MA and their tonal perception and production. Furthermore, in order to unravel how different types of ME specifically influence learners’ tonal perception and production respectively, further studies based upon a larger sample size may elaborate understanding of learners’ age of ME onset, instrumental ME or vocal ME, both instrumental and vocal ME, as well as early ME or late ME.

2) Among the four MA subtests, Pitch height had the strongest correlation with Mandarin tonal perception, and pitch contour had the strongest correlation with Mandarin tonal production for NNS of Chinese. This finding confirms the findings of previous studies. However, this finding in present study was based upon monosyllables and disyllable tones. In order to evaluate how NNS and NS perceive and produce the target tones differently future research may pay more attention to the Mandarin tones in syntactic structures and connected speech.

3) In addition to the effect of MA, learners’ LE in the form of bilingualism seems to play an influential role in their tonal perception and production. Integrating MA with LE to examine learners’ tonal perception and production has not been noted in previous studies. The findings and discussion may explain why previous studies reached inconsistent conclusions, and may also contribute to a refinement of existing findings on the link between learners’ MA and tonal perception, as well as tonal production. In order to refine the research design, future research should enlarge the sample sizes of the bilingual and monolingual speakers.
4) After one-semester of tonal learning experience in the formal teaching classroom (i.e. the training conditions were both communicative and instructional, focusing on both form and meaning), learners’ MA no longer played a role in their tonal perception and production. This finding reveals the crucial role of tonal learning experience/training in enhancing learners’ tonal perception and production, and diminishes the effect of MA. In other words, the key factor determining learners’ ultimate success in tonal perception and production is not in the long run innate MA and learned/trained MA, but rather the external tonal learning experience/training. First, this finding reflects that the effect of MA is not sustained to the later stage of learners’ learning, but being temporary at the early stage of their learning. This result from the current longitudinal study accounts for the inconsistent results from the prior studies discussed in sections 1.5.6 and 1.5.8 in the Introduction Chapter. Specifically, those prior studies supporting the close link between music and language may have only conducted the early stage testing, whereas previous studies opposing this close link may have only undertaken the late stage testing. Second, this finding has a teaching pedagogy implication: in order to maximize learners’ tonal experience it is hoped this finding may inspire teachers of Mandarin Chinese to emphasise the importance of tonal training when teaching their students. From the learners’ perspective, the finding encourages them to make a particular effort in tonal learning. Ultimately, their learning success may be improved through their external effort rather than as a result of their MA. The implications of this finding may be generalized to a wider context, in the sense that language teachers and learners in general, and tonal language teachers and learners more specifically can benefit from it. Future studies might enlarge the sample size at the later stage testing to re-evaluate the
correlation between MA and MLT, and between MA and MST, as well as to compare and contrast the performance at both stages of testing. The focus of future research should also be on how tonal learning experience affects learners’ tonal perception and production, rather than on how musical training affects learners’ tonal perception and production as has been done in most prior studies.

4.6. Summary of the chapter

This chapter has discussed the findings of the current study and related them to the wider literature, showing areas of convergence and divergence with previous studies, and setting the findings in a wider framework of issues around the effect of MA (i.e. a combination of innate MA and learned/trained MA) in perceiving and producing Mandarin tones by NNS of Chinese.
Chapter 5: Conclusion

5.1 Overview of the chapter

This chapter provides the six key findings of the study, discusses their pedagogical implications and possible contributions, points out the limitations of the study, suggests avenues for further research, and provides the final conclusions.

5.2 Summary of the research process

The major object of this study was to explore the effect of musical aptitude defined as a combination of innate MA and learned/trained MA (i.e. ME) in tonal perception and tonal production by non-native learners of Chinese. As apparent in the research questions, the relationship between Mandarin learners’ musical aptitude and their tonal perception, as well as between their musical aptitude and their tonal production, was evaluated in the study by both early and late stage testing. Conducting both sets of tests helped to reveal whether the musical aptitude of NNS of Chinese helps in their perception and production of Mandarin lexical tones, both in the initial stage of their learning and over time. The motivation for addressing this issue was two-fold. First, it stemmed from the inconclusive findings in previous research regarding the relationship between music and language in general, as well as between musical aptitude and tonal languages in specific. Second, very little specific research had been conducted on the relationship between Mandarin learners’ musical aptitude defined as a combination of innate MA and learned/trained MA and their tonal perception, as well as tonal production. One main research question and five research sub-questions were thus formulated to address the effect of musical aptitude on learners’ tonal perception and production in Mandarin Chinese.
5.3 Research questions

To reiterate, the main research question and research sub-questions are as follows:

**Main research question:**

Does musical aptitude help non-native speakers of Chinese in their perception and production of Mandarin lexical tones at different stages of their learning?

**Research sub-questions:**

RQ #1: How should musical aptitude (MA) be defined?

RQ #2: Is there a significant correlation between non-native speakers (NNS)’ MA and their perception and production of Mandarin tones?

RQ #3: What aspect of MA provides the most advantage in NNS’ tonal perception and tonal production respectively?

RQ #4: Are there other factors in addition to MA that play a role in NNS’ Mandarin tonal perception and production?

RQ #5: If MA is a factor in Mandarin tone perception and production, does its impact change over time?

5.4 Summary of the key findings

The key findings from both stages of testing are summarized as follows:

First, a statistically significant positive medium correlation was found between learners’ innate MA and their MLT, as well as between innate MA and their MST. Subsequently, a statistically strongly significant positive moderate/medium correlation was observed between learners’ different levels of ME and their innate
MA, and a statistically significant positive medium correlation was found between learners’ ME and their tonal perception, but an insignificant weak correlation was observed between learners’ ME and tonal production. These findings overall suggest a complex and dynamic relationship between learners’ innate MA, learned/trained MA, tonal perception and tonal production. Learners’ innate MA and different levels of ME (i.e. learned/trained MA) were intricately interwoven in terms of affecting their tonal perception and production. On the one hand, the interwoven relationship between learners’ innate MA and ME assisted in refining the definition of MA as one which may combine both the innate nature of MA and years of ME. The elaboration of the definition of MA answers the first research question. On the other hand, both innate MA and learned/trained MA (i.e. ME), which together can be defined as MA, overall revealed a significant moderate/medium correlation with learners’ tonal perception and production. It is evident that innate MA and ME are inextricably linked and the mixed results make it difficult to determine which one is more important. These mixed results overall respond to the second research question.

Second, the MA Pitch subtest was found to have the strongest correlation with the MLT, and the Melody subtest had the largest correlation with the MST, both of which were statistically significant. These findings are a response to the third research question, and show that pitch height plays an important role in the perception of tones by NNS and that pitch contour plays a crucial role in the production of tones by NNS (Gandour, 1983; Shen, 1990; Wang et al., 2003; Yang, 2010).

Third, in addition to MA, learners’ LE in the form of bilingualism was found, as expected, to have an impact on learners’ tonal perception and production. This finding which confirmed previous research results relates to Research Question 4.
The above key findings revealed that MA played an influential role in affecting the
learners’ tonal performance in listening and speaking. It can, therefore, be concluded
that MA did help the NNS of Chinese in their perception and production of Mandarin
lexical tones in the early stage of learning, where in particular, the pitch aspect of MA
provides the most advantage in learners’ tonal perception, and the melody aspect of
MA provides the most advantage in their tonal production. Learners’ LE in the form
of bilingualism, in addition to MA, played a role in their tonal perception and
production.

Fourth, after one semester (i.e. 60 classroom hours = 5 classroom hours per week*
over 12 weeks) of tonal learning experience (i.e. the tonal training took place in the
formal teaching classroom; the training conditions were both communicative and
instructional, focusing on both of forms and meanings), it was found in the later stage
testing that the learners had made significant improvements on the MLT and MST.
These improvements suggest that the increase in tonal experience may have enhanced
their tonal performance in perceiving and producing the target lexical tones. The
learners’ MA test scores in the later stage testing appeared to be similar to those from
the early stage testing, where learners’ MA did not change notably as their tonal
experience increased. Concurrently, it was found that MA no longer had a significant
correlation with the MLT and MST, which suggests that MA played a lesser role in
the learners’ MLT and MST in the later stage testing, compared to its significant
moderate correlation with the MLT and MST in the early stage testing. The findings
from the longitudinal study (i.e. early stage testing and later stage testing) revealed the
different effects of MA in perceiving and producing Mandarin lexical tones by NNS
of Chinese. In short, as learners’ tonal learning experience increased, the impact of
observed MA on learners’ tonal perception and production had become lesser over

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time, an observation which answers the last research sub-question. In response to the main research question, all of the six key findings jointly indicate that MA may help NNS of Chinese in their perception and production of Mandarin lexical tones at the early stage of their learning, but that their MA may not necessarily be as important at the later stage of their learning.

5.5 Theoretical contributions and pedagogical implications

This study provides some important insights and makes significant contributions to research on the relationships between music and language in general, more specifically between musical aptitude and tonal language, and particularly musical aptitude-Mandarin tones, at theoretical, methodological, and pedagogical levels. In terms of theory the research results contribute to a refinement of existing theories about the link between Mandarin learners’ MA and their tonal perception and production. Different factors have been found in prior research to contribute to learners’ difficulty in perceiving and producing Mandarin lexical tones. These factors included the categorical nature of tone, the phonetic cues for tone, the context-dependent nature of tone sandhi, learners’ LE such as bilingualism, the learner’s age at L2 exposure and their foreign language anxiety, as well as the impact of gender. Although these factors were found to contribute to learners’ difficulty in their tonal perception and production, the learning difficulty and problems for learners remain unsolved. In regard to each of these few studies had particularly investigated the tentative link between learners’ musical aptitude (MA) and their Mandarin lexical tonal perception, as well as between MA and tonal production. In other words, little research has thus far been conducted on another potential factor affecting learners’ perception and production of Mandarin lexical tones: learners’ MA. Results from the
small body of research which had investigated the tentative link between learners’ musical aptitude (MA) and their Mandarin lexical tonal perception, as well as between MA and tonal production, were inconsistent: some investigators found little or no relationship between musical aptitude and second language learning of tone (e.g. Poeppel, 2001; Anvari et al., 2002), but other investigators had found such a relationship to exist (e.g. Zatorre et al., 2002; Slev & Miyake, 2006; Wong et al., 2007). Clarifying this inconsistency, the present study overall discovered a significant, positive moderate/medium correlation between learners’ MA and their tonal perception, as well as tonal production.

However, the effect of MA diminished over an extended period of time as learners’ tonal training in the formal classroom setting increased. This more conclusive evidence aids in refining existing theories about the link between musical aptitude and Mandarin tones. Concurrently, none of the previous studies had clarified the precise strength (i.e. small/weak, medium/moderate, large/strong) of the relationship between music (aptitude) and language in general, or specifically between MA and Mandarin learners’ lexical tonal perception, as well as tonal production. It is evident that the current study clarified the precise strength of the correlation between MA and learners’ tonal perception and production. These findings overcome the imprecision of the previous research undertakings in this field.

Briefly, in order to detect whether learners’ MA helps in their tonal perception and production, the current study vigorously investigated the effect of MA, defined as a combination of innate MA and learned/trained MA, on tonal perception and production by NNS of Chinese. Among the four MA subtests, the MA Pitch subtest had the strongest correlation with Mandarin tonal perception, and the MA Melody
subtest had the strongest correlation with Mandarin tonal production for NNS of Chinese. These findings confirm the results of previous studies. In addition to the effect of MA, learners’ LE in the form of bilingualism also seems to affect their tonal perception and production. This combination had not been noted in previous studies, a factor which might explain why prior studies arrived at inconsistent findings with respect to the relationship between music and language, and it is this the effects of this combination which contribute to a refinement of existing findings on the link between learners’ MA and tonal perception, as well as tonal production.

The present study also makes a contribution to current research methodology. Specifically, the study helps to elaborate the definition of MA which had not been precisely defined in prior studies. Most previous studies were neuro-scientific and psychophysiological, and focused on trained/learned (i.e. ME) MA rather than on both of innate MA/talent/genetics and trained/learned. In other words, few of them precisely defined MA so as to be able to select the most appropriate MA test for their particular research aims. No research has yet applied a MA test corresponding to the primary key acoustic cues of Mandarin lexical tone, including pitch height, pitch contour, loudness and duration. In addition, other variables in the previous studies were not well controlled. These include the specific language being investigated (e.g. most previous studies either focused on the Language in general, or particularized Cantonese tone, but the current study focused on Mandarin lexical tones.), and the aspects of MA and language skills being investigated (e.g. most of the studies focused on only partial aspects of MA such as melody or timbre). Furthermore, whether language perception and production were both assessed in each of the previous studies was not clearly stated. This is important as these are two separate dimensions of acquiring a foreign language. Moreover, most previous studies focused on tones in
syntactic structure instead of monosyllables and disyllables and most compared the NS of Mandarin Chinese to English speakers. Few studies compared NNS monolingual English speakers to bilingual speakers who speak diverse additional languages. Lastly, none of the studies carried out a longitudinal study to investigate the association between MA and tonal perception, as well as tonal production. These limitations made the generation of statistically reliable and valid findings unlikely. For the purpose of providing more rigorous and conclusive research results regarding the relationship between learners’ MA and their Mandarin tonal perception, as well as tonal production, the present study refined the research design in the ways indicated above.

Finally, the findings of the present study carry some important pedagogical implications. After one-semester of tonal learning experience, learners’ MA no longer played a role in their tonal perception and production. This finding reveals the crucial role of tonal learning experience/training in enhancing learners’ tonal perception and production, and diminishes the effect of MA. Similarly, the key factor determining learners’ ultimate success in tonal perception and production is not in the long run innate MA and learned/trained MA, but rather the external tonal learning experience/training. Most previous studies examined how musical training influenced language performance, rather than how tonal learning experience/training affected tonal performance. The result of the present study regarding the role of learners’ tonal learning experience in their tonal perception and production has the following teaching pedagogy implication: in order to maximize learners’ tonal experience teachers of Mandarin Chinese should emphasise the importance of tonal training when teaching their students. From the learners’ perspective, the finding encourages them to devote particular effort to tonal learning. Ultimately, their learning success
may be improved through their external effort rather than as a result of their MA. The implications of this finding may be generalized to a wider context, in the sense that generally language teachers and learners and more specifically tonal language teachers and learners, can benefit from it.

5.6 Limitations and suggestions for future research

In spite of its useful findings, the present study has several limitations, which caution us about the results obtained on the one hand, and provide possible routes for future studies on the other.

To begin with, although innate MA, learned/trained MA and bilingualism were found to play an influential role in learners’ tonal perception and production in the early stage testing of the present study, it cannot be denied that other variables/factors might have contributed to the learners’ enhanced tonal perception and production. These variables, which could not be controlled for in this study, could include learners’ learning style, learning strategies, learning time and effort invested outside the classroom, learning motivation, tonal language experience, age, gender, memory, confidence, self-esteem, teachers’ pedagogy in the classroom (Thogmartin, 1982; Horwitz et al., 1986; Johnson & Newport, 1989; 1991; Holmes, 2001; Burman, 2008). Future studies should take these variables into account and expand the sample size of bilingual speakers and monolingual speakers. Additionally, in order to re-evaluate the correlation between MA and MLT, and between MA and MST, as well as to compare and contrast performance at both stages of testing, future studies should also expand the sample size of the participants in the later stage testing. The focus of future research should also be on how tonal learning experience affects learners’ tonal perception and production, rather than on how musical training affects learners’ tonal
perception and production, as has been done in most prior studies. In addition, in order to unravel how different types and levels of learned/trained MA (i.e. ME) specifically influence learners’ tonal perception and production, further studies based upon a larger sample size may elaborate understanding of learners’ age of ME onset, instrumental ME or vocal ME, both instrumental and vocal ME, as well as early ME or late ME.

Second, Key Finding #3 was drawn from monosyllables and disyllable tones only, which implies that pitch height and pitch contour are the most important or primary acoustic cues for Mandarin monosyllables and disyllables. However, other acoustic cues such as loudness/amplitude and time/duration could start to play equally important roles when the Mandarin tones are built upon connected speech or syntactical structures (Dow, 1972; Yip, 2002; Sanders, 2008). Hence, this result should not be generalized to wider contexts such as connected speech or syntactical structures. In order to evaluate how NNS and NS perceive and produce the target tones differently in a wider context, future research may investigate Mandarin tones in syntactic structures and connected speech.

Finally, the sample size of the tonal language speakers was extremely limited in the present study, and therefore the statistical significance could not be determined. By expanding the sample size of tonal language speakers, future research may re-evaluate how tonal language speakers perform differently from non-tonal language speakers in terms of the perception and production of Mandarin lexical tones. Concurrently, at the later stage testing, the sample size of bilingual speakers and monolingual speakers may be enlarged. Doing this may aid in determining whether BS continuously
perform significantly better than MS on tonal perception and production at the later stage of their learning.

5.7 Conclusion

Mandarin speakers use tones to lexically distinguish word meanings, and therefore learning Mandarin tone appears to be as essential to communication, as consonants and vowels in the English language. A number of studies have found that those learning Mandarin as a foreign language have difficulty in perceiving and producing Mandarin lexical tones (Klein et al., 2001; Wang et al., 2001a; 2003; Lee et al., 2009). In order to tackle this problem and therefore improve Mandarin learners’ learning, researchers have attempted to detect the source for this difficulty. Different contributory factors have been found, these include the categorical nature of tone, the phonetic cues for tone, the context-dependent nature of tone sandhi, learners’ bilingualism, learner’s age, foreign language anxiety and the impact of gender (Chao, 1968; Brown, 1980; Hassler et al., 1985; Xu, 1997; Peretz & Coltheart, 2003; Wee, 2008). Little research has thus far been conducted on another potential factor affecting learner’s perception and production of Mandarin lexical tones: learners’ musical aptitude. Results from the small body of research have been inconsistent: some investigators found little or no relationship between musical aptitude and the second language learning of tone (e.g. Poeppel, 2001; Anvari et al., 2002), but other investigators have found such a relationship to exist (e.g. Zatorre et al., 2002; Slev & Miyake, 2006; Wong et al., 2007). Therefore, the current study represents a step forward in the field of music/musical aptitude-language/tonal language/Mandarin tones relationships towards a more comprehensive and thorough understanding of the way in which musical aptitude helps NNS of Chinese in their perception and
production of Mandarin lexical tones during different stages of their learning. To achieve this understanding, the study explored the relationship between learners’ musical aptitude defined as a combination of innate MA and learned/trained MA and their tonal perception, as well as tonal production, at both stages of testing. It is the researcher’s belief that the study’s findings, as well as the discussion and suggestions contained within, will benefit Mandarin learners, teachers and educators, as well as tonal language learners, teachers and educators, and contribute to existing theories about the link between Mandarin learners’ MA and their tonal perception and production. Ultimately, it is hoped that the study makes a contribution to our understanding of the dynamic and complex relationship between MA and learners’ tonal perception, as well as between MA and learners’ tonal production.
Appendices

Appendix 1 Questionnaire

Investigating Language & Musical Background

➢ Language background

1. Family Name ____________   Personal Name ____________
2. Gender: Male  Female
3. Home Phone___________   Mobile phone______________
   E-mail Address____________________________________
4. Date of Birth (dd/mm/yyyy):________________________________
5. Primary Language ______________________________________
   Other language(s) spoken fluently________________________________
6. Have you ever lived in a Chinese-speaking country?
   Yes (→Q 7)   No (→Q 8)
7. Where ____________ and for how long ________________?
8. Where are/is your parent(s) from? _______________________
9. How long have you lived in NZ? _________________________
10. Years of study at the University of Auckland______________
11. Academic major _____________   minor___________________

➢ Musical background

12. Which of the following describes your musical experience?
Circle one

(A) I have had musical instruction (→Q 13)

(B) I have not had musical instruction, but have actively participated in amateur musical activities (→Q 22)

(C) I enjoy listening to music but have never been actively involved in any musical activity. (→Q 23)

(D) I don’t enjoy listening to the music and have never participated in musical activities. (→Q 23)

13. How old were you when you started to have music instruction? _____

14. Do you play one or more instrument(s)? Yes (→Q 15) No (→Q 17)

15. Which musical instrument(s) do you play? ____________________________

16. Do you still play? Yes No

17. Have you ever had vocal instruction? Yes (→Q 18) No (→Q 19)

18. What vocal range do you sing? ____________________________

19. How many years did/has your musical instruction last(ed)? ____________

20. In addition to musical instruction how many of the following musical activities have you done? Circle all that apply

(A) Music appreciation classes at school or university

(B) Music theory lessons

(C) Music composition

(D) Musical theatre (singing and dancing)

(E) Other ____________________________
22. How many of the following musical activities do you have experience with?

Circle all that apply and indicate whether you actively performed (A) or were a spectator (S) in the parentheses (  )

(A) Solo recitals (  )

(B) Chamber group (  )

(C) Orchestra (  )

(D) Band (  )

(E) Small vocal ensemble (  )

(F) Choir (  )

(G) Opera (  )

(H) Musical theatre (  )

(I) Ballet (  )

(J) Ballroom dancing (  )

(K) Other types of dance (  )

(L) Karaoke (  )

(M) Other _________________(  )

23. Do you have any comments regarding your musical experience?
Appendix 2  Mandarin Listening Test (MLT)

Mandarin Lexical Tones:

Listening Test

(Student’s Version)

*Please circle the tone that you hear for each item.*

- **Monosyllables**

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➤ Disyllables

*Please note:* the 1<sup>st</sup> row of four tone marks is for the 1<sup>st</sup> syllable, and the 2<sup>nd</sup> row is for the 2<sup>nd</sup> syllable.

*If it is neutral tone you hear, you don’t need to circle any tone mark.*
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Appendix 3  Mandarin Speaking Test (MST)

Mandarin Lexical Tones:

Speaking Test

(Student Version)

Please read out the following lexical tones loudly.

➢ Monosyllables

1. ăi
2. biê
3. duî
4. găo
5. jiăo
6. kăn
7. măî
8. nă
9. qiăn
10. rèn
11. shŭ
12. tă
13. wŏ
14. xîng
15. yăo
16. zăo
17. chăo
18. fĕng
19. hŭî
20. kāi
21. lǎn
22. ná
23. pá
24. xuě
25. yú

➢ Disyllables:

26. rìběn
27. tóngxué
28. xiōngdì
29. bǔxíng
30. máobǐ
31. lǎoshǐ
32. dōngxī
33. hǎokàn
34. huàbào
35. zǎijiàn
36. báicài
37. cēsuǒ
38. chúfāng
39. diànhuà
40. diànhī
41. fēijī
42. dōngxī
43. gānmào
44. hěn hǎo
45. gōngkè
46. jiānglái
<p>| | |</p>
<table>
<thead>
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<tr>
<td><strong>47.</strong></td>
<td>jīnzhāng</td>
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<tr>
<td><strong>48.</strong></td>
<td>kètīng</td>
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<tr>
<td><strong>49.</strong></td>
<td>lìbài</td>
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<tr>
<td><strong>50.</strong></td>
<td>píngcháng</td>
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<td><strong>51.</strong></td>
<td>ránhòu</td>
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<td><strong>52.</strong></td>
<td>wòfāng</td>
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<tr>
<td><strong>53.</strong></td>
<td>yīshēng</td>
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<tr>
<td><strong>54.</strong></td>
<td>xiōngdì</td>
</tr>
</tbody>
</table>
Appendix 4  Mandarin Listening & Speaking Tests

Mandarin Lexical Tones:

Listening & Speaking Test

(Researcher’s Version)

➢ Monosyllables

1. ěi
2. bǐe
3. duì
4. gāo
5. jiào
6. kàn
7. mǎi
8. nǎ
9. qián
10. rèn
11. shǔ
12. tā
13. wò
14. xìng
15. yào
16. zǎo
17. chǎo
18. fēng
19. huǐ
20. kāi
21. lân
22. ná
23. pá
24. xuể
25. yú

➢ Disyllables

26. rìběn
27. tóngxuè
28. xiōngdì
29. bùxíng
30. máóbì
31. lǎoshī
32. dōngxi
33. hǎokàn
34. huàbāo
35. zàijiàn
36. báicài
37. cēsuǒ
38. chúfāng
39. diānhuà
40. diàntǐ
41. fēijī
42. dōngxī
43. gānmào
44. hén hāo
45. gōngkē
46. jiānglái
47. jīnzhāng
48. kètīng
49. lǐbài
50. píngcháng
51. ránhòu
52. wòfāng
53. yīshēng
54. xiōngdì
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