PHONOLOGICAL AWARENESS IN MANDARIN OF CHINESE AND AMERICANS

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Phonological awareness (PA) is the ability to analyze spoken language into its component sounds and to manipulate these smaller units. Literature review related to PA shows that a variety of factor groups play a role in PA in Mandarin such as linguistic experience (spoken language, alphabetic literacy, and second language learning), item type, tone context, musical ability, and talker variability. However, most of previous studies focus on the PA of Mandarin tones; only few studies have compared native speakers of Chinese and of other world languages on all levels of PA in Mandarin.

The present study is a factorial examination of the effect of various factor groups discussed above on all levels of PA in Mandarin (syllable awareness, onset awareness, rhyme awareness, and tone awareness) by four groups of participants with different linguistic experience, each group having 10 participants. The first and second groups

American English with or without learning experience with Mandarin. Participants were given a syllable same-different task, an onset oddity task, a rhyme oddity task, and a tone identification task. Logistic regression and Chi Square analyses were performed on the responses to these tasks to determine the conditioning effect of different factor groups. Error analyses were also conducted to examine error patterns of the tone awareness task.

In addition to confirming the heterogeneity of overall PA established in earlier research, the results demonstrate the relative contributions of several factor groups such as alphabetic literacy, item type, and tone context and raises questions about the relevance of several others such as musical ability and sex of talker. It also provides implications for instructional practice.

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CHAPTER 1 INTRODUCTION

Phonological awareness (PA) is the ability to recognize internal auditory segments of words and manipulate them mentally (Sodoro, Allinder, & Rankin-Erickson, 2002; Stuart-Smith & Martin, 1999). It is also the awareness of sounds in spoken language relative to speech sounds in print (Bentin, Hammer, & Cahan, 1991; Jones & Munhall, 2002).

PA research started with native speakers of English, an alphabetic language. Previous studies have examined different types of PA: syllable awareness, onset awareness, rhyme awareness, and phoneme awareness. The underlying rationale of PA research is the well-acepted hierachical view of the syllable structure which posits that the syllable consisits of subunits, an onset and a rhyme, which are smaller than the syllable and larger than the phoneme. Research by Treiman (1985, 1986, 1995) on speech errors, short-term memory errors, word games, and the perception of phonological units provides evidence for the hierachical onset and rhyme structure.

Previous research with alphabetic languages, especially English, has found that both linguistic and non-lingusitic variables are related to PA. Three major ones related to lingusitic experience have been identified: (1) spoken language prior to alphabetic reading instruction; (2) alphabetic knowledge identified as a result of literacy or explicit training on the alphabetic principle; and (3) the learning of at least one second language or foreign language. PA research has investigated to a lesser extent whether or not item type (presence or absence of L2 test items in L1) affects PA. Non-linguistic variables that have been investigated include musical ability and talker variability.

Although the alphabetic system dominates world languages, pioneers in the study of PA such as I. Y. Liberman (Liberman, Shankweiler, Fisher, & Carter, 1974) and Treiman (1985, 1986, 1995) have called for the expansion of such research using the techniques used with speakers of alphabetic languages to examine the PA of logographic languages such as Chinese and Japanese. Experimental work examining the PA of Chinese speakers and learners has focused on Mandarin, the official Chinese language, and has yielded converging evidence with research on speakers of alphabetic langauges. Spoken language, alphabetic knowledge (e.g., *Pinyin*), L2 learning experience, musical ability, and talker variability all have been found to facilitate PA in Mandarin. It has also been found that tone context has an effect on PA of Chinese speakers and learners.

However, previous research on Mandarin has several limitations. First, many studies of Mandarin focus exclusively on the PA of tone, especially the acquisition of tone by native speakers of Mandarin (e.g., Li & Thompson, 1977; Wong, Schwartz, Jenkins, 2005; Zhu, 2002; Zhu & Dodd, 2000); only a few studies have compared speakers of different languages (e.g., Chen et al., 2004; Halle, Chang, & Best, 2004; Liow & Poon, 1998; McBride-Chang, Bialystok, Chong, & Li, 2004). More research is needed to explore the difference between speakers of Chinese and of other world languages. Second, although Mandarin is also learned and spoken as a second language by a large number of the Chinese whose first language is not Mandarin, existing studies typically ignore this group of subjects. Therefore, non-Mandarin Chinese speakers' PA needs to be further explored. Third, little is known about the effect of item type, musical ability, and talker variability on PA in Mandarin. Therefore, more research is needed to investigate the relationship between different variables and all types of Mandarin PA.

By examining the simultateous effect of several independent variables on all types of PA in Mandarin by participants with different linguistic experience, the present study aims to (1) determine what variables contribute to patterns of difference across native and nonnative speakers of Chinese, (2) conbtibute new findings to research with speakers of alphabetic langauges and of Chinese, and (3) provide implications for teaching Mandarin to non-native speakers of Chinese.

This study addresses the call by Liberman and Treiman for additional research by extending PA research on alphabetic languages to logographic languages like Chinese. By doing so, it can help determine whether PA in Mandarin is developed in the same way predicted by current linguistic theories concerning PA. This study also contributes to a small body of research on the nature of PA in Mandarin. It provides further information about the relationship between different types of Mandarin PA and a variety of variables. Additionally, this study speaks to the learning of Mandarin by non-native speakers of Chinese. The recent devleopment of Chinese economy has made other nations realize the urgency of including foreign Mandarin instruction in school curricula. By examining areas of strength and weakness in participants' performance, this study has implications for teaching Mandarin to learners of different linguistic backgrounds.

This dissertation is organized into the following chapters. Chapter 2 presents a review of relevant research on PA in both alphabetic langauges and Chinese. It begins with the lingusitic status hypothesis which laid the foundation for the research on the development of PA. Different types of PA are introduced, and their developmental patterns are compared. Next, the relationship between these types of PA and a variety of linguistic and non-linguistic variables is discussed. This is followed by a review of relevant research with Chinese speakers and learners. Chapter 3 begins with the research questions and hypotheses of the present study and introduces the study's methodology. Chapter 4 reports the results from analysis of the responses to the experimental tasks. The effect of different variables is examined, and patterns of error are analyzed. Chapter 5 provides a general discussion of the results in relation to previous research. Implications for future studies and Mandarin teaching are also provided. This is followed by a summary of the major findings of the present study.

CHAPTER 2 LITERATURE REVIEW

Phonological Awareness

Phonological awareness (PA) is not "an all-or-none phenomenon" (Treiman & Zukowski, 1996, p. 67). Stuart-Smith and Martin (1999) offer a summary of types of PA based on phonological units: syllable awareness is the awareness of the number of syllables of a word; phoneme awareness is the awareness of the componential sounds of a syllable or word; and onset/rhyme awareness is the awareness of intermediate units between syllables and phonemes. The heterogeneous nature of PA requires that its assessment consist of a variety of tasks which tap participants' abilities to isolate and manipulate phonological units. These include the ability to count syllables or to judge their similarity, to determine whether two items rhyme with each other, to judge whether items share initial consonants or onsets, to count individual phonemes in a syllable or word, to delete a specified phoneme, to blend several phonemes, or to locate a specific phoneme within a larger unit.

Although the syllable has been recognized by all major approaches to phonology including the early Prague School, London Prosodicists, American Structuralists, and Generative Phonology (Blevins, 1995), no agreement has been reached concerning the syllable's internal structure. The linear view (e.g., Clements & Keyser, 1983) claims that syllables are composed of phonemes with no intermedial level between the syllable and the phoneme as shown in Figure 1a. An alternative hierachical view holds that the syllable is composed of subunits (e.g., Blevins, 1995; Fudge, 1969, 1989; Halle & Vergnaud, 1980; Selkirk, 1982; Treiman & Zukowski, 1991). Of several hierachical views, the most influential in PA research is the linguistic status hypothesis proposed by Treiman and her colleagues (Bruck, Treiman, & Caravolas, 1995; Treiman, 1985, 1986; Treiman & Zukowski, 1996). This view posits that an intermediate level of structure, composed of an optional onset and a rhyme, exists between the syllable and the phoneme (see Figure 1b). The obligatory rhyme includes the vowel nucleus and any following consonant(s).

(1a) (1b)

Figure 1. Views of the syllable.

Evidence for the hierarchical structure comes from both linguistics and psycholinguistics. For example, Treiman (1983, 1984) points out that, whereas co-occurrence is possible between any English onset and any rhyme, co-occrrence between codas and vowels is highly constrained. That is, in English a short vowel can co-occur with a tri-consonantal coda (as in *dimple*), but a long vowel cannot. (*Deemple* is not an English word.) English rules of stress assignment also apply only to rhymes. Evidence is also provided by research on speech errors (Fromkin, 1971; Mackay, 1970, 1972), word games (Treiman, 1983, 1985, 1986; Treiman, Fowler, Gross, Berch, & Weatherston, 1995), short-term memory errors (Treiman, 1995; Treiman & Danis, 1988), and the perception of phonological units (Barton, Miller, & Macken, 1980; Treiman, 1980; Treiman, Salasoo, Slowiaczek, & Pisoni, 1982; Treiman & Zukowiski, 1991, 1996).

The linguistic status hypothesis has laid the foundation for assessing awareness of different phonological units. Sufficient experimental work has been done to suggest that PA is a three-level ability which includes four types of PA: syllable awareness, onset/rhyme awareness, and phoneme awareness.

Høien, Lundberg, Stanovich, and Bjaalid (1995) examined different levels of PA in Norwegian preschool children using six tasks: (1) a rhyme recognition task requiring the identification of words which rhymed with target words, (2) a syllable counting task, (3) an initial-phoneme matching task that required identifying a picture depicting a word whose initial sound was the same as a word uttered by the experimenter, (4) an initial phoneme deletion task that required choosing a picture depicting a word which was the remainder of an orally presented word after its initial sound was deleted, (5) a phoneme blending task, and (6) a phoneme counting task. The results showed three clear levels of PA: a syllable level, a rhyme level, and a phoneme level.

Humle et al. (2002) examined English-speaking children's PA of onsets, rhymes, and intial and final consonants. Three computerized tasks were used to assess each type of PA. An initial phoneme detection task asked the children to match a non-word stimulus to one of three non-word choices, e.g., /smɪg/ followed by /suk/ [target], /klɪd/ [distracter], and /nab/ [distracter] (p. 7). A rhyme oddity task asked the children to identify the odd word in a list of three words, e.g., /smɪg/-/saf/ [target]-/trɪg/ (p. 8). The children were also required to delete a specified unit from a non-word, e.g., /spot/--/pot/ (p. 8). The results revealed various degrees of difficulty with the PA measures, indicating that phonological components place different demands on speech perception. The heterogeneous nature of PA underlies the necessity for including different phonological units when measuring PA.

PA research has been focused on exploring what independent variables impact the development of PA for different groups of participants and how different levels of PA are linked to each variable. It has been found that both linguistic and non-linguistic variables influence the PA of speakers of alphabetic languages. Linguistic variables relevant to this study include spoken language, alphabetic literacy, L2 learning experience, and item type. Relevant non-linguistic variables are musical ability and talker variability. These studies are discussed below.

Spoken Language and PA

It has been found that spoken-language experience modifies pre-reading children's PA. As Caravolas and Bruck (1993) point out, preliterate children are exposed to phonological characteristics of their native languages. As a result, language-specific PA patterns emerge. Goswami (1999) also suggests that "differences in the phonological input provided by different languages should affect the development of children's awareness of the different phonological levels" (p. 139). To examine the effect of spoken language, cross-linguistic studies have been conducted comparing preliterate children speaking different languages.

Cossu, Shankweiler, Liberman, Katz, and Tola (1988) divided Italian preschool children into Group A (members of the second-year preschool class) and Group B (members of the third-year). The children were further divided into two groups, one given syllable segmentation tasks and the other phoneme segmentation tasks. Comparing the results with those from Liberman et al. (1974) with English-speaking children, Cossu et al. reported that Italian children scored significantly better than English children on both tasks. They attributed the result to the differences between the two spoken languages: Italian has a smaller number of vowels and simpler syllable structure than English. They suggested that this makes syllable and phoneme segmentation tasks in Italian easier than in English.

This issue was further explored by Caravolas and Bruck (1993) who compared Czech- with English-speaking children in prekindergarten and kindergarten on two oral tasks. All tasks had parallel forms in both languages. A same-different task asked the children to judge whether a pair of CVCC non-words shared the same onset (e.g., /***s***emp/-/***s***oold/) or whether a pair of CCVCs shared the same initial phoneme (e.g., /***f***las/-/***f***reb/) (p. 11). No significant difference was found between Czech and English children on this task. In a sound isolation task, the children were asked to repeat a CCV or CVC word and then to say the first sound. Whereas Czech children performed significantly better on CCV items than English children did, English children scored better on CVC items. Caravolas and Bruck interpreted the findings as demonstrating the effect of oral language input on performance patterns: Czech has more complex onsets than English, consistent with Czech children's better performance on CCVs; English has more CVC words and more evident onset-rhyme distinction, consistent with English children's better performance on CVCs.

Bruck, Genesee, and Caravolas (1997) compared English- and French-speaking kindergarten children attending schools in their native languages in Montreal. Tasks testing syllable awareness, onset/rhyme awareness, and phoneme awareness used non-words presented orally. Whereas French children performed significantly better on the syllable counting task, English children were superior on the onset and phoneme awareness tasks. The authors pointed out that the most salient unit in processing spoken French is the syllable while it is the phoneme in English. They also indicated that French monosyllabic words have a more open (CV) syllable structure. Like Caravolas and Bruck (1993), therefore, these results reveal the effect of language-specific phonological characteristics in spoken languages on preschool children.

Alphabetic Literacy and PA

Studies that investigate beginning readers have found that reading acquisition is more strongly related to PA than intelligence, age, and task (Wagner & Torgesen, 1987). Developmental research has revealed that syllable and rhyme awareness develop before children learn to read an alphabetic script, while onset and phoneme awareness emerge after reading begins (Lenel & Cantor, 1981; Liberman et al., 1974; Maclean, Bryant, & Bradley, 1987; Stanovich, Cunningham, & Cramer, 1984; Yopp, 1988). A dramatic gap has been found between preschool children and beginning readers in terms of phoneme segmentation skills (e.g., Bruce, 1964; Treiman & Zukowski, 1991). Most preschool children can divide a word into syllables but cannot segment words into phonemes. They can identify rhymes but have difficulty detecting onsets (Morais, Alegria, & Content, 1987). There is also converging evidence from English-speaking children that syllable and rhyme awareness develop independently of literacy background, but that PA at the phonemic level does not develop in the absence of alphabetic literacy or explicit training on phonemic analysis (e.g., Lenel & Cantor, 1981; Liberman et al. 1974; Stanovich et al. 1984; Yopp, 1988). This finding has led Bertelson and de Gelder (1991) to argue for the importance of differentiating among different levels of PA and investigating their separate relationships with reading.

Liberman (Liberman, 1973; Liberman et al. 1974; Liberman, Shankweiler, Liberman, Fowler, & Fisher, 1978; Liberman, Shankweiler, & Liberman, 1989) drew attention to the relationship between phoneme awareness and the acquisition of reading skills. She suggested that an inability to map strings of sounds onto strings of letters renders it difficult for beginning readers to decode alphabetic orthography. She also noted that phoneme awareness does not develop spontaneously and, like reading, does not develop in every normal child. As she proposed, “The most powerful predictors of later reading and writing skills [are] those requiring phonological awareness, specifically the analytical ability to manipulate phonemes in words” (Liberman et al., 1989, p. 13). However, it remains unclear whether phoneme awareness is a prerequisite (e.g., Adams, 1990; Ball & Blachman, 1988; Bradley & Bryant, 1983; Christensen, 1997; Cunningham, 1990; Fox & Routh, 1975; Goswami & Bryant, 1990; Hatcher, Hulme, & Ellis, 1994; Lundberg, Olofsson, & Wall, 1980; Treiman & Baron, 1983), a consequence (e.g., Alegria, Pignot, & Morais, 1982; Bowey & Francis, 1991; Bradley & Bryant, 1978; Lundberg, Frost, & Petersen, 1988), or both (e.g., Cheung, 1999; Liberman et al., 1989).

Another line of research explores the effect of alphabetic literacy on phoneme awareness. The contribution of Morais and his colleagues is of paramount importance to this area of research. According to their view, learning to read highlights explicit knowledge of the phonological structure of an alphabetic language and sensitizes learners to implicit knowledge acquired from listening and speaking. Under this view, the ability to segment speech does not necessarily develop with cognitive growth but emerges with special training, which, for most people, is alphabetic literacy (Morais et al., 1987). Thus, although syllable and rhyme awareness emerge naturally, learning to read an alphabetic orthography is necessary for the acquisition of phoneme awareness. As Morais (1991) states, “people can acquire phonological awareness without reading instruction, but they can acquire phonemic awareness only when provided with instruction on some written code [alphabetic code]” (p. 16).

Consistent with Morais’ views, a large number of studies have suggested that learning to read an alphabetic script gives rise to, or at least facilitates, the development of phoneme awareness. Empirical support has come from studies of children that compared (1) participants with different amounts of schooling; (2) poor and normal readers; and (3) readers learning with different types of instruction. There have also been studies of adults with and without literacy problems.

Bowey and Francis (1991) compared a group of Australian kindergarten children and two groups of first graders on oddity tasks. The effect of group was significant. The two first-grade groups achieved similar performance, and both outperformed the kindergarten group on all tasks. Bentin et al. (1991) compared first graders and kindergarten children in Jerusalem on phoneme segmentation tasks. They also found schooling to be a major contributor to participants’ phoneme awareness, larger than age. Bertelson, de Gelder, and van Zon (1997) tested kindergarten and first grade children on initial consonant deletion and initial consonant compasiron tasks. First graders outperformed kindergarteners in both tasks in this study as well.

Bradley and Bryant (1978) compared normal readers to a group of readers whose reading skills lagged at least 18 months behind their peers. Both groups were of normal intelligence. The normally developing children were on average three years younger than the delayed readers. The results of their onset and rhyme oddity tasks revealed significant differences between the two groups: Whereas 91.66% of delayed readers made errors, only 53.33% of normal readers did so. Morais, Cluytens, and Alegria (1984) tested dyslexic children and normal readers on syllabic and phonemic segmentation tasks. Comparison showed a significant advantage of normal readers over children with dyslexia on all subtests, especially on phonemic segmentation which all dyslexic children failed. Error analysis indicated that children with dyslexia had more severe problems with phonemic segmentation than with syllabic segmentation. Bruck and Treiman (1990) also tested first- and second-grade children with dyslexia and normal readers on phoneme recognition and deletion. The two groups showed significant differences for both tasks.

Alegria et al. (1982) compared the PA of first-grade children in Brussels who were learning to read with either a phonic or a whole-word method. The phonic method decomposed words into subsyllabic units while the whole-word method did not. A segmentation task required the children to reverse the syllables in uttered disyllabic words, e.g., to say [dira] for [radi] (p. 452). The children were also asked to reverse the order of the phonemes of uttered words, e.g., to say [os] for [so] (p. 452). Analysis revealed a significant effect for group (phonic or whole word) and condition (syllabic or phonemic reversal). The syllabic condition showed significantly better performance than the phonemic condition for the two groups, and the gap between these two tasks was larger for the whole-word group than for the phonic group.

Morais, Cary, Alegria, and Bertelson (1979) presented two tasks to illiterates and literates from a Portuguese agricultural community who learned to read as adults: (1)

saying words and non-words without one of their sounds and (2) adding sounds to words and non-words. Half of the illiterate participants failed each test whereas all literate participants passed at least one of the tests (see Table 1).

Table 1

Percent Correct Responses for Illiterate and Literate Portuguese Adults

Task	Illiterate group		Literate Group	
	Word	Non-word	Word	Non-word
Deletion	26	19	87	73
Addition	46	19	91	71

The performance of the illiterates led Morais et al. to conclude that the emergence of phoneme awareness is associated with learning to read an alphabetic orthography.

In another study with illiterate and literate groups from Portugal, Morais, Bertelson, Cary, and Alegria (1986) tested participants on a battery of PA tasks. The finding in Morais et al. (1979) was confirmed; the illiterates were unable to delete an initial consonant while the literates were able to do so. The illiterate group’s lack of segmentation skills at the phonemic level was also indicated by their difficulty detecting target sounds and in progressive free segmentation tasks. Since both groups were equally able to segment melodies and recall pictures, the researchers concluded that differences in groups’ ability to segment speech did not result from the differences in general ability or short-term retention. The illiterate group attained a better performance on syllabic vowel deletion (more than half of the participants reached the 75% correct level) and rhyme detection (nearly half of them reached that level) than on consonant detection (none of them reached that level) although their performance was inferior to that of the literate group on all these tasks. The researchers concluded that only phoneme awareness requires literacy in an alphabetic orthography. Consistent with previous research (e.g., Lenel & Cantor, 1981; Liberman et al. 1974; Stanovich et al. 1984; Yopp, 1988), the results also indicate that syllable and rhyme awareness may develop spontaneously with general cognitive and linguistic growth and do not require support from reading an alphabetic script.

Morais et al. (1987) compared three groups of female Portuguese adults aged 38-63: illiterates, semiliterates (who only occasionally read or wrote), and literates. Participants listened to recorded Portuguese words and repeated them. The results showed significantly better performance by literates than by semiliterates and illiterates who did not differ significantly from each other. The literates' superiority revealed that alphabetic literacy increased their awareness of the internal structure of words. Similar results have also been obtained in Brazil by Bertelson, de Gelder, Tfouni, and Morais (1989); in Australia by Bryne and Ledez (1983); and in the United States by Liberman, Rubin, Duques, and Carlisle (1985) and Read and Ruyter (1985).

However, it has also been found that phoneme awareness can develop with training on phonemic analysis rather than formal alphabetic literacy. For example, Lundberg (1991) based on evidence from Lundberg et al. (1980) and Lundberg et al. (1988) reveals that some children develop phoneme awareness without learning an alphabetic orthography. Mann (1991) makes the same argument based on longitudinal studies of beginning readers by Bradley & Bryant (1985), Mann (1984), and Stanovich et al. (1984) and on studies of readers of non-alphabetic orthography (e.g., Mann 1986). While recognizing that experience with an alphabetic script facilitates the development of phoneme awareness, Mann maintains that other experiences like language games, songs, or verses may also develop phoneme awareness. As a result, she suggests replacing "knowledge of an alphabetic orthography" with "experience in manipulating the internal structure of words" (1991, p. 61). Lundberg et al. (1988) who trained Danish preschool children to attend to the phonological structure of language and measured the effect of training on the children's progress in PA tasks in first and second grades offer strong evidence for this position. A small but significant effect was observed on rhyming tasks and on tasks involving word and syllable manipulation. The training effect was also significant for tasks requiring phoneme manipulation.

Second Language Learning and PA

The research discussed above focuses on the effect of L1 alphabetic knowledge of monolingual speakers. There is also a growing body of research that investigates the effect of L2 experience on the development of PA. These studies compare PA of monolingual and bilingual children using one or both of the bilinguals' languages.

Rubin and Turner (1989) examined the differences between two groups of English-speaking first-grade children: one group enrolled in an early French immersion program at kindergarten and the other group enrolled in a standard English program. Participants were directed to analyze an orally presented English word into syllables (e.g., say *butterfly* without *butter*) or phonemes (e.g., say *mom* without /m/). Children in the French immersion program performed significantly better than monolingual children, demonstrating a positive effect for bilingualism.

Campbell and Sais (1995) compared monolingual English and bilingual English-Italian kindergarten children in the UK on two PA tasks. In a sublexical deletion task, the experimenter gave the children two puppets A and B and told them that when A said *ice* *cream*, B said *cream*. Using new words, the experimenter played A and asked the children to play B. The same procedure was used for the syllable deletion of CVCV nonsense words. The results of a letter detection task that asked the children to identify a letter on a printed card showed that the two groups had similar letter knowledge. Despite this, the bilingual children scored significantly better on the two PA tasks than the monolingual children did. In particular, Campbell and Sais suggest that segmentation skills may develop earlier in bilingual children than monolingual peers.

A study by Bruck and Genesee (1995) suggests that bilingualism may affect only some aspects of PA. They administered a battery of English PA tests to monolingual English-speaking children attending an English-medium school and bilingual English-speaking children attending a French-medium school in kindergarten and grade one. The children were tested on syllable awareness, onset/rhyme awareness, and phoneme awareness tasks. The results revealed that in kindergarten the bilingual children had significantly better onset/rhyme awareness. However, this advantage disappeared in grade one. The authors attributed the change to both maturation and reading instruction. The monolingual children outperformed their bilingual peers on phoneme awareness tasks, though. The authors attributed this effect to the monolingual children learning English spelling-pronunciation associations that were not learned by the bilingual children learning to read in French.

Loizou and Stuart (2003) studied four groups of five-year olds in the UK and Cyprus: bilingual English-Greek and monolingual English children, bilingual Greek-English children and monolingual Greek children. Syllable awareness, onset/rhyme awareness, and phoneme awareness tasks were administered to the monolingual children in their native languages and to the bilingual children in both languages. English bilingual children were superior to monolingual children on all English tasks but syllable completion and rhyme oddity. However, no superiority was observed for Greek bilingual children over their monolingual peers. Loizou and Stuart suggest that the effect of bilingualism may depend on phonological complexity since, in their view, Greek has a simpler phonological structure than English.

Bialystok, Majumder, and Martin (2003) reported studies of English-French bilingual and monolingual English children in kindergarten, grade one, and grade two. In the first study, the children were given an English phoneme substitution task which asked them to make a new word by replacing the initial sound of a stimulus with the initial sound of another word in three conditions. In the no-cue condition, for example, the children were directed to replace the beginning sound of the word *cat* with the beginning sound of the word *mop*. In the sound condition, the children were told to substitute the m-sound from *mop* for the k-sound from *cat*. In the picture condition, the children were presented with the pictures of a mop and a cat. While no overall difference was found between the two groups, an interaction of condition and group revealed the bilingual children's advantage in the no-cue condition and the monolingual children's superiority in the sound condition. A second study used the same tasks and procedure except that the bilingual children were tested in both languages. Again, no overall effect of bilingualism was observed. The monolingual children had an advantage over the bilingual children in the sound condition when the latter were tested in English. Since the first two studies showed no bilingual advantage, one more study was conducted to compare monolingual English, bilingual Chinese-English, and bilingual Spanish-English children from grade one and two on two PA tasks, a phoneme segmentation task and a phoneme substitution task. The effect of group was significant for the phoneme segmentation task. Spanish-English children had the best performance, followed by the monolingual and Chinese-English children. The authors attributed this result to English being phonologically more similar to Spanish (e.g., neither is a tonal language). They also suggest that the relatively simpler phonological structure of Spanish may enhance PA. Consistent with Bruck and Genesee (1995), the three studies failed to show a general bilingual advantage.

Since research has reported contradictory results for the role of bilingualism in promoting PA, it may be more accurate to say, as Bruck and Genesee (1995) conclude, that "bilingualism has selective rather than universal effects on the development of phonological awareness" (p. 319). Viewed from this perspective, research suggests that a bilingual advantage depends on several factors. If the L2 is phonologically simpler than the L1, bilingualism seems to facilitate the development of PA. However, this advantage seems to disappear with reading instruction; with literacy, monolingual children catch up with bilingual peers. Moreover, bilingualism has a facilitating effect not on PA skills in general, but on awareness of specific phonological units.

Item Type and PA

The above studies focus mainly on PA in participants' L1. Several studies seek to examine how second and foreign language learners perceive the phonology of their L2s. L2 learners are known to have difficulty acquiring some phonological categories but have no difficulty at all with others. Several frameworks have been established to predict this difficulty. One important framework is Eckman's (1977) *Markedness Differential Hypothesis*, which defines unmarked forms as those common to many languages and marked forms as those less common, predicting that areas of the target language that are more marked than the native language will be more difficult to learn. In addition, Stockwell and Bowen (1983) suggest a difficulty order based on the absence or presence of L2 phonological structures in learners' L1.

Cross-language studies of adult non-native consonant perception (Miyawaki et al., 1975; Polka, 1991; Takata & Nábělek, 1990) speak to this question. Miyawaki et al. (1975) tested the perception of English synthetic [ra]-[la] continua by native speakers of English and Japanese. American participants obtained a ceiling performance whereas Japanese participants' performance was slightly better than chance, reflecting the absence of a [ra]-[la] contrast in Japanese. Takata and Nábělek (1990) also compared native speakers of English and Japanese. They asked participants to listen to six English words differing in the initial or final consonant and to circle the word they thought they heard on an answer sheet. English speakers performed significantly better than Japanese speakers. The consonants that presented perceptual difficulty to Japanese speakers were absent in Japanese such as /θ/, /f/, and /v/. Polka (1991) analyzed English speakers' perception of four Hindi retroflex vs. dental stop consonants. The results indicated significant differences in the performance on these contrasts. Performance correlated with the listener's perception whether or not a Hindi contrast was similar to an English one.

Evidence is also available from adult perception of non-native vowels. Bohn and Flege (1990) compared an English control group and two groups of native German speakers, experienced and inexperienced learners of English. Participants were asked to perceive two English vowel contrasts, /ɛ/-/æ/ and /i/-/ɪ/. Bohn and Flege found that the two German groups showed no difference in the identification of the /i/-/ɪ/ contrast but substantial difference in the identification of the /ɛ/-/æ/ contrast. This disparity was attributed to the presence of an /i/-/ɪ/ contrast and to the absence of /æ/ in German. This, they suggest, posed a learning difficulty for inexperienced native Germans unfamiliar with /æ/ due to their limited English competence. Polka (1995) tested monolingual speakers of Canadian English on the perception of two German vowel contrasts, /y/ vs. /u/ and /ʏ/ vs. /ʊ/. Although the participants demonstrated a high level of accuracy for both contrasts, they had more difficulty discriminating the /ʏ/ vs. /ʊ/ contrast because they were less likely to map the /ʏ/ vs. /ʊ/ contrast onto English vowel categories.

Musical Ability and PA

Research has also found a statistically significant relationship between non-linguistic variables such as musical ability and PA. Music and speech represent two important sound-based activities sharing a "generative nature" (Zatorre, Belin, & Penhume, 2002, p. 37) and systematic pitch variation (Alexander, Wong, & Bradlow, 2005). By studying previous research, Besson and Schön (2003) note that an area important to speech in the brain is active when musicians play music. The right side of the brain, which is believed to be important to PA, is also active when musicians think about music. These shared features lay the foundation for a correlation between early musical skills and PA since, as Anvari, Trainor, Woodside, and Levy (2002) explain, the basic learning process for speech and music is similar. To learn speech, one must learn basic elements of increasing complexity: phonemes, syllables, words, and syntactic constituents. The elements of music—rhythms, melodies, and harmonies—are also hierarchically structured and learned in a developmental sequence. Since speech and music involve some of the same auditory analysis skills, as Anvari et al. (2002) posit, musical training may enhance linguistic skills such as blending and segmenting sounds.

Anvari et al. (2002) observed that all PA skills were correlated with rhythm pattern and chord skills for groups of four and five years old Canadian children. Montague (2002) found significant correlations between children's phoneme awareness and rhythm pattern skills. Moritz (2007) examined whether musical training promotes PA. In both fall and following spring semesters, the author tested two groups of 5-year-olds, one group receiving 225 minutes of musical instruction per week in daily 45-minute lessons and the other group receiving 35 minutes per week of musical instruction in one weekly lesson. Analysis showed a significant relationship of onset/rhyme and phoneme awareness with musical skills in both fall and spring. The fall to spring comparison revealed that the group with intensive musical instruction made greater improvements in PA tasks and was able to do more difficult PA tasks than the group with less musical instruction.

Talker Variability and PA

A second non-linguistic variable that also has an impact on speech perception is variation in talker information. Creelman (1957), Verbrugge, Strange, Shankweiler, and Edman (1976), Mullennix, Pisoni, and Martin (1989), and Sommers, Nygaard, and Pisani (1992) all show that naturally produced words were more accurately identified when drawn from tokens produced by a single talker than when drawn from tokens produced by talkers that included men, women, and children. Another source of variability results from talker sex. K. Johnson (1991) tested undergraduate American students on identification of synthetic [ʃ] to [s] continua produced by a male and a female speaker. Significantly more tokens produced by the female speaker were identified as [ʃ].

In summary, research indicates that PA is not a unified skill. Both linguistic and psycholinguistic evidence provides strong support for the onset/rhyme division in English speakers' processing phonological structures. Moreover, evidence shows that children develop syllable awareness earlier than onset/rhyme awareness which emerges earlier than phoneme awareness. Developmental research also suggests a close relationship between the three levels of PA and the acquisition of alphabetic literacy. Research with speakers of alphabetic languages demonstrates that alphabetic experience facilitates the development of phoneme awareness for both children and adults and that the phonological characteristics of various languages give rise to different PA patterns. The literature also shows that alphabetic literacy interacts with spoken language and L2 learning experience to promote PA when other variables such as age, IQ, and verbal knowledge are controlled. In addition, research on PA demonstrates that phonological difficulties that foreign or second language learners encounter depend on the degree of sound correspondence between the target language and native language and the learner's familiarity with the target sounds. The literature also suggests that musical ability enhances PA and that sex of talker influences perception at the phonological level. With these issues largely settled, in recent years, research on the PA of speakers and learners of a logographic language (e.g., Chinese) is receiving growing attention.

Chinese and PA

Traditionally, spoken Chinese is divided into eight major varieties: (1) Northern Speech, (2) Kejia, (3) Northern Min, (4) Southern Min, (5) Xiang, (6) Gang, (7) Wu, and

(8) Yue. The eight varieties (or languages according to Western linguistics), which have their own distinctive features, are mutually unintelligible. Each language has sub-varieties or dialects; for example, Cantonese is a sub-variety of Yue (Zhu, 2002). *Pǔtōnghuà*, known as Mandarin in English-speaking countries, is a standardized language norm based on the phonological and grammatical system of a Northern Speech sub-variety, the Beijing dialect (Sun, 2006; Zhu, 2002). Although Northern Speech is spoken by 70% of the Chinese in the People's Republic of China (PRC), the Beijing dialect is spoken only in the capital city. Children are usually taught *Pūtōnghuà* from elementary school but are not discouraged from speaking their own languages or dialects. Thus, most Chinese are at least bilingual, and many are multilingual. Mandarin is also used as the official language known as *Guóyǔ* (literally 'national language') in Taiwan and is one of four official languages referred to as *Huáyǔ* (literally 'Chinese language') in Singapore. For the convenience of English-speaking readers, the following uses *Mandarin*.

The same writing system, Chinese characters, is used to represent all of the mutually unintelligible languages because a character represents the same morpheme in print regardless of its pronunciation. Cantonese-speaking children in Hong Kong do not draw on an alphabetic system to learn to read Chinese characters. Rather, characters are taught in the pronunciation of Cantonese words by a *look and say* method: children learn characters by rote. They learn English as L2 using the same whole-word method. As a result, they are not encouraged to practice subsyllabic segmentation skills (Cheung, 1999, 2003; Ho & Bryant, 1997; Holm & Dodd, 1996; Huang & Hanley, 1995; McBride-Chang et al., 2004). Children in Mainland China and Taiwan who are learning to read are taught the pronunciation of Mandarin words even if they are native speakers of other languages

(Hanley, Tzeng, & Huang, 1999). Children in Mainland China learn to read Chinese characters using *Pinyin*, a "phonological transparent orthography with one-to-one grapheme-phoneme correspondences" (Bassetti, 2006, p. 99), to represent the sounds of Mandarin. Children in Taiwan learn to read through a different phonetic system called *Zhuyin fuhao*. Its letters are unique visual symbols derived from ancient Chinese characters whereas *Pinyin* symbols are represented by Roman orthography (Huang & Hanley, 1997).

Pinyin has superseded *Zhuyin fuhao* as the standard romanization for Mandarin internationally. *Pinyin* is used to teach spoken Mandarin not only to Chinese who speak other Chinese languages at home but also to those who learn Mandarin as a foreign or second language. The following discussion of Mandarin phonology uses the *Pinyin* system.

The basic speech unit in Mandarin is the syllable. Each morpheme (one Chinese character) is monosyllabic. Traditionally, a Mandarin syllable is divided into three parts: an initial (onset), a final (rhyme), and a tone (Chao, 1948, 1968; Chen, 1999; Li & Thompson, 1981). Compared with English, Mandarin syllable structure is simple because no initial consonant clusters are allowed. The optional onset in a Mandarin syllable is a single consonant (C). Each syllable has a nuclear vowel. This vowel may combine with another vowel to form a diphthong. The rhyme begins with an optional medial vowel (M), followed by the nuclear vowel (V) or diphthong (VV) and an optional nasal consonant (N). This can be represented by (C) (M) V (V/N) (Li & Thompson, 1987; Sun, 2006).

Mandarin onsets with the IPA notations in brackets and italicized *Pinyin* letters are shown in Table 2 adapted from Chao (1968, p. 22):

Table 2

Mandarin Onsets

Manner / Place	Unaspriated Stops	Aspriated Stops	Nasals	Fricatives	Voiced Continuants
Labials	[p] *b*	[pʰ] *p*	[m] *m*	[f] *f*	
Dentals	[t] *d*	[tʰ] *t*	[n] *n*		[l] *l*
Dental sibilants	[ts] *z*	[tsʰ] *c*		[s] *s*	
Retroflexes	[ʈʂ] *zh*	[ʈʂʰ] *ch*		[ʂ] *sh*	[ɻ] *r*
Palatals	[tɕ] *j*	[tɕʰ] *q*		[ɕ] *x*	
Gutturals	[k] *g*	[kʰ] *k*		[x] *h*	

Mandarin consonants that correspond to English sounds are *b* [p], *p* [pʰ], *m* [m], *f* [f]*; d* [t], *t* [tʰ], *n* [n], *l* [l]*; g* [k], *k* [kʰ]*; z* [ts], *s* [s]; and *r* [ɻ]. A second group, comprised of *c* [tsʰ], *h* [x], *j* [tɕ], *q* [tɕʰ], *x* [ɕ], *zh* [ʈʂ], *ch* [ʈʂʰ], and *sh* [ʂ], do not occur in English. These pose problems to English-speaking learners of Mandarin.

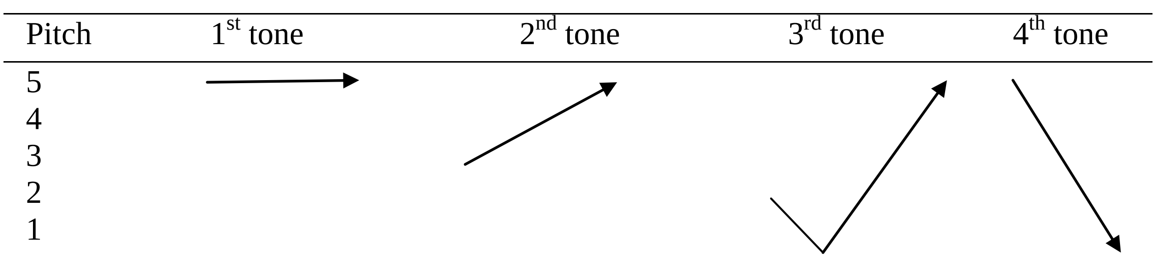
Mandarin rhymes are divided into three types (Wu, Yu, Zhang, & Tian, 2006). As shown in Table 3, simple rhymes contain a single vowel (V). Compound rhymes are diphthongs (VV) or combine a medial vowel (*i* [i], *u* [u], or *ü* [y]*)* with other vowels (MV and MVV). Nasal rhymes combine [n] or [ŋ] with a medial + vowel (MVN) or with a single vowel (VN). Like Mandarin onsets, a number of Mandarin rhymes do not correspond to English sounds. The five single vowels *a*, *o*, *e*, *i*, and *u* are closely equivalent to English sounds [a], [ɔ], [ə], [i], and [u], respectively. The four diphthongs *ai*, *ei*, *ao,* and *ou* are similar to English sounds [aɪ], [e], [aʊ], and [o]. In addition, the nasal rhymes *in* and *ing* correspond to English [ɪn] and [ɪŋ]. Other rhymes have no close equivalents in English and are harder for English-speakers to learn.

Table 3

Mandarin Rhymes

Simple rhymes (V)		*a* [a], *o* [uɔ], *e* [ə],, *i* [i], *u* [u], *ü* [y]
Compound rhymes	VV	*ai* [ai], *ei* [eɪ], *ao* [ɑʊ], *ou* [oʊ]
	i+V(V)	*ia* [ia] , *iao* [iɑʊ], *ie* [iɛ], *iu* [ioʊ]
	u+V(V)	*ua* [ua], *uo* [uɔ], *uai* [uai], *ui* [ueɪ]
	ü+V	*üe*[yə]
Nasal rhymes	VN	*an* [an], *en* [ən] , *ang* [ɑŋ], *eng* [əŋ], *ong* [ʊŋ]
	i+VN	*ian* [iɛn], *in* [in], *iang* [iɑŋ], *ing* [iŋ], *iong* [yʊŋ]
	u+VN	*uan* [uan], *un* [uən], *uang* [uɑŋ], *ueng* [uəŋ],
	ü+VN	*üan* [yɛn], *ün* [yn]

Mandarin has lexical tones that determine the meaning of a Mandarin word. Stressed syllables have one of four basic tones. The diagram provided by Sun (2006, p. 39) helps visualize the pitches of the four tones:



Pinyin uses either numbers or tone marks. Morphemes with the same onset and rhyme but with different tones have different meanings. This is illustrated in Table 4 below:

Table 4

Mandarin Words with Different Tones

Pinyin	Chinese characters	Tone	Meaning
mā 1	妈	High level	mother
má 2	麻	Rising	hemp
mǎ 3	马	Falling rising	horse
mà 4	骂	Falling	scold

There is a small but growing body of research exploring independent variables that facilitate different levels of PA for Chinese speakers and learners. As with research on speakers of alphabetic languages, evidence has shown that spoken language, alphabetic literacy, L2 learning experience, musical ability, and talker variability condition PA of Chinese speakers and learners in Mandarin. It has also been found that tone context has an effect on PA in Mandarin. Such research is presented below.

Some studies have explored the relationship between PA development and spoken-language experience. In Cheung, Chen, Lai, Wong, and Hills (2001), for example, three groups of pre-readers—Cantonese-speaking children in Guangzhou, Mainland China; Cantonese-speaking children in Hong Kong; and English-speaking children in New Zealand—were asked to match syllables, onsets, rhymes, or codas with a target. The Chinese children listened to Cantonese syllables, while the English children listened to English syllables. There were no significant differences between Guangzhou and Hong Kong pre-readers who spoke the same language and had limited literacy. The two Chinese groups were then pooled and compared with the English group. The latter was significantly better than the former in all levels of PA except for syllable awareness, suggesting that the more complex phonological structures of spoken English boosted English-speaking children's PA.

Cheung (2003) studied the interaction between *Pinyin* instruction and spoken-language experience with English-Cantonese speaking children born in New Zealand who were learning to read Chinese. One group was learning to read via a character-based orthographic method; the other group via *Pinyin*-based alphabetic instruction. The children were tested on a coda-deletion task before and after instruction. The first test showed that the children generally deleted codas more accurately from items with the nuclear vowel *i* than from those with *yu*. Chueng interpreted this result as reflecting the children's pre-literacy experience because in Cantonese syllables with *i* are more frequent than syllables with *yu*. This difference was found only for the orthographic group in the final test, indicating that interaction between the *Pinyin* instruction and spoken language mediates phoneme awareness.

Studies have also examined the relationship between PA and alphabetic experience. Since the Chinese writing system is logographic, Chinese children do not need to attend to subsyllabic units when reading Chinese characters. However, they pay attention to smaller units if they learn characters through *Pinyin* or *Zhuyin fuhao*. With such alphabetic systems, Chinese speakers are sensitized to phonological structures and use grapheme-phoneme correspondence rules. Those without such experience like Cantonese-speaking Chinese in Hong Kong are less likely to notice phonological information and thus decode Chinese characters as units. The effect of *Pinyin* alphabetic knowledge has been assessed by comparing (1) Chinese pre-readers and beginning readers, (2) Chinese children with and without knowledge of *Pinyin* or *Zhuyin fuhao*, and (3) Chinese adults with and without alphabetic knowledge.

Huang and Hanley (1997) conducted a longitudinal study of the relationship between PA in Mandarin and reading of Taiwanese grade one students. The children were pretested before receiving *Zhuyin fuhao* instruction and were retested ten weeks later, right after the instruction, and one year later. All tests consisted of two phoneme awareness tasks, odd man out and phoneme deletion. The results indicated that for both tasks performance improved significantly across all three tests, suggesting a strong influence of alphabetic experience on phoneme awareness. Shu, Peng, and McBride-Chang (2008) examined Mandarin-speaking children from three kindergarten grades and one primary grade. The children were given syllable, rhyme, onset, and tone detection tasks. Significant differences were found between the children in kindergarten and those in primary school on the onset and tone detection tasks, indicating the effect of *Pinyin* instruction on onset and tone awareness, but not on syllable and rhyme awareness.

McBride-Chang et al. (2004) compared children with *Pinyin* literacy from Xian, Mainland China and those without it from Hong Kong. Some children from Xian and all children from Hong Kong could read both Chinese characters and English. English syllable deletion and onset deletion tasks were administered to Hong Kong and Xian bilingual children. The same Chinese tasks were given to Xian monolingual children in Mandarin and to Hong Kong children in Cantonese. A significant effect of *Pinyin* instruction was observed for phoneme deletion. Xian monolingual children performed significantly better than Hong Kong children on the Chinese tasks. The result is consistent with Huang and Hanley (1995) with Mandarin-speaking primary school children in Taiwan and Cantonese-speaking counterparts in Hong Kong, which showed Taiwan children's superiority over Hong Kong children on phoneme awareness tasks. McBride-Chang et al. suggest that the *Pinyin* literacy of the Xian bilingual children helped them attain significantly better performance not only on Mandarin but also on English tasks. Their result also corresponds to that of Leong, Cheng, and Tan (2005) who compared Mandarin-speaking grade four and five children in Beijing who started to learn English at grade four and one group of Cantonese-speaking peers in Hong Kong.

Read, Zhang, Nie, and Ding (1986) was an early study of adult Chinese speakers' PA. They examined two groups of participants: adults only literate in Chinese characters (the non-alphabetic group) and those who had also learned *Pinyin* (the alphabetic group). As in Morais et al.'s (1979) study with Portuguese adults, the participants were instructed to add or delete a consonant (/d/, /s/, or /n/) at the beginning of a spoken Mandarin syllable. Both groups performed significantly better on words than on non-words. The alphabetic group's performance was like that of the Portuguese literate group, and the non-alphabetic group's performance was like that of the Portuguese illiterate group, consistent with Morais et al.'s suggestion that alphabetic literacy rather than literacy in general affects phoneme awareness.

Read et al. (1986) inspired additional studies on the effect of alphabetic experience on adult Chinese speakers' PA. Leong and Hsia (1996) investigated phoneme awareness of Cantonese-speaking university students learning English in Hong Kong. Participants were assigned to two groups, one of which received *Pinyin* training. Both groups completed segmental analysis of initial and final consonants of orally-presented English CCVCC pseudo-words and of initial consonants of spoken Cantonese words. The *Pinyin* group's performance was significantly better than that of the other group except for the segmentation of English final consonants, suggesting that the *Pinyin* training boosted onset awareness not only in Cantonese but also in English.

Holm and Dodd (1996) compared PA skills of four groups of university students in Australia with different first languages and different orthographic literacy. Three groups of them were English language learners: (1) a PRC group that had learned to read *Pinyin*, (2) a Hong Kong group that had no *Pinyin* experience, and (3) a Vietnamese group whose L1 was an alphabetic language. The fourth group spoke Australian English. Participants completed three English PA tasks: (1) phoneme segmentation which asked students to identify the number of sounds of an orally presented word, (2) spoonerisms which instructed students to switch the first phonemes of a word pair, e.g., *big dog—dig bog* (p.125), and (3) rhyme judgment which directed students to determine whether a pair of words rhymed with each other. Analysis of phoneme segmentation showed that PRC and Australian students performed significantly better than Vietnamese students who performed significantly better than Hong Kong students. For spoonerisms and rhyme judgment, the Hong Kong group attained significantly inferior performance to all other groups. Taken together, these findings point to Hong Kong students' inferior subsyllabic segmentation skills due to their lack of alphabetic literacy.

Studies have consistently demonstrated that alphabetic experience, be it *Pinyin* (Holm & Dodd, 1996; Leong et al., 2005; Leong & Hsia, 1996; McBride-Chang et al., 2004; Read et al., 1986; Shu et al., 2008) or *Zhuyin fuhao* (Huang & Hanley, 1995, 1997), is positively associated with phoneme awareness for speakers of Chinese, while syllable and rhyme awareness seem not to be influenced by such experience.

Like studies with speakers of alphabetic languages, research with Chinese speakers has yielded contradictory results for the effect of L2 learning experience. Some studies have found a bilingual advantage. For example, Liow and Poon (1998) investigated the PA of bilingual (English and Mandarin) L1 speakers and trilingual Bahasa Indonesia L1 speakers. All children (aged 9-10) were from primary 3 of a government school in Singapore. All of them had formal instruction in written English, Chinese characters, and *Pinyin* instruction, so the effect of literacy was controlled for. Three PA tasks were used: (1) a written English homophone decision task which asked the children to judge whether two letter strings sounded alike, e.g., *die-dye* (p. 349); (2) an English lexicality spelling test, and (3) a *Pinyin* spelling test. For the first and second tasks, Bahasa-Indonesian students performed significantly better than English and Chinese students. No effect was found for the *Pinyin* spelling test, probably due to all of the children's limited exposure to *Pinyin*. The authors suggest that the superiority of Indonesian students was due to their experience with two L2s.

Other studies have only found a selective effect for bilingualism. Chen et al. (2004) tested three types of Mandarin PA: onset awareness, rhyme awareness, and tone awareness. They compared Cantonese-Mandarin bilingual second- and fourth-grade speakers from Guangzhou and Mandarin monolingual counterparts from Beijing in Experiment 1 and added first graders to their subject pool in Experiment 2. The authors suggest that the bilingual Cantonese-speaking children had developed better onset and rhyme awareness by second grade due to their bilingual experience and the more complex phonological structure of their first language. However, there was no significant difference between fourth-grade Cantonese- and Mandarin-speaking Children. The authors suggest that bilingual experience may not have a lasting effect on the development of children's PA. In terms of tone awareness, Cantonese-speaking children had better tone identification than Mandarin-speaking children in the first grade. The authors attributed this result to the fact that Cantonese has a more complicated tone system than Mandarin.

Bialystok, McBride-Chang, and Luk (2005) compared English monolingual children and English-Cantonese bilingual children in Canada and Cantonese-speaking children learning English as a L2 in Hong Kong. Syllable and phoneme awareness tasks were administered in English for Canadian monolingual children and in both languages for the bilinguals. It was found that on the English phoneme deletion task, Canadian monolingual and bilingual children scored significantly higher than their Hong Kong peers. On the English phoneme counting task, Canadian bilingual children were not significantly different from either of the other two groups that differed significantly from each other. Additionally, whereas Canadian bilingual children were significantly better at the Cantonese syllable deletion task than the Hong Kong children were, their performance on the Cantonese phoneme deletion task was significantly worse than their Hong Kong peers. Thus, the results did not show an overall effect of bilingualism. The authors conclude that "bilingualism on its own has little direct role in influencing the establishment of [PA]" (p. 588).

Some research focuses exclusively on Mandarin tone awareness. There are two kinds of studies. The first examines the effect of linguistic experience on tone awareness. Studies comparing native speakers of Mandarin and native speakers of English indicate that Mandarin speakers' tone awareness is superior to that of English speakers due to their language-specific tonal knowledge. Other studies show that training can improve tone awareness of speakers of non-tonal languages. The second area of research examines accuracy of tone identification by native speakers of non-tonal languages.

Lee, Vakock, and Wurm (1996) looked at differences in tone perception for speakers of tonal and non-tonal languages. All participants were university students: Mandarin-speaking students in Taipei, Cantonese-speaking students in Hong Kong, and English-speaking students in Stony Brook, NY. Experiment 1 used Cantonese tone pairs. After hearing each pair, the participants were directed to judge whether the two tones were the same or different. The effect of linguistic experience was significant. The Cantonese group's performance was superior to that of the other groups. Experiment 2 used the same procedure with Mandarin words and non-words. The Taipei students were replaced by Mandarin-speaking students from Mainland China. As in Experiment 1, native speakers scored the best among the three groups. In this experiment, however, the Cantonese group significantly outperformed the English group. This was attributed to the fact that Cantonese has a complex tone system.

Bent, Bradlow, and Wright (2006) compared native speakers of Mandarin and native speakers of English with no exposure to Mandarin on the perception of Mandarin tones. The stimuli, Mandarin real words and nonsense syllables, were presented through headphones. Listeners identified tones by pressing one of four buttons, each corresponding to a tone. Significant differences were observed for the two groups with an accuracy rate of 99% for the Chinese vs. 58% for English speakers. Additionally, whereas the English group exhibited a large performance range (26% to 88% correct), the Mandarin group's performance varied only slightly (96% to 100% correct).

Leather (1990) investigated the impact of production training on tone perception. Dutch participants were trained to produce four Mandarin tones in single syllables. In the perception test, the participants were presented with a stimulus used in the training followed by “What is this?” The participants answered by pressing a computer key labeled with a word corresponding to one of four tones. The participants’ tone performance was highly accurate, indicating an effect for training of speakers of a non-tonal language. The author also reports that tones 2/3 provided the greatest difficulty for the participants.

In a pilot study, Wang, Jongman, and Sereno (1998) chose eight U.S. college students enrolled in a second year Mandarin Language course, four trainees and four controls. All participants took a pretest. During one-week of training, trainees listened to tone pairs recorded on a tape and determined which tone they heard. Immediately after the training, both trainees and controls took a posttest that was similar to the pretest. Although statistical analyses exhibited no significant effects for test (pre, post) or group (trained, control) due to the small number of participants and variability among the trainees, the results showed an improvement from the pretest (77%) to posttest (88%) for the trainees, while the controls improved only from 78% to 80%. Comparison of the pre- and posttests also revealed that the tone 2/3 pair was the most confusing for the trainees in both tests.

In a second study, Wang, Spence, Jongman, and Sereno (1999) increased the sample size to eight trainees and eight controls. In a two-week program, trainees were taught to identify the four tones in 100 natural words. After the training, both the trainees and the controls took a posttest in which they were asked to identify the tones of the stimuli used in the pretest as well as novel stimuli recorded by new talkers. Comparison of the two groups revealed significant difference in the posttest, but not in the pretest. The trainees' identification accuracy improved by 21% from the pretest to posttest for both old and new stimuli, while the controls' performance improved by only 3%. As for individual tones, the trainees showed no significant differences among four tones either in the pre- or the posttest. Analysis of tone confusion revealed that most confusing tone pair in the posttest was tones 2/3 as in Leather (1990) and Wang et al. (1998).

Kiriloff (1969) examined beginning learners of Mandarin at an Australian college on the identification of isolated syllables with four Mandarin tones. The first two tasks tested participants' tone identification and phoneme transcription, and the third task tested tone identification alone. The participants attained a 23.5% error rate in the first two tasks which was significantly different from a 12.1% error rate in the third task. As for individual tones, tone 2 was least accurately identified, and tone 4 and tone 1 were the most accurately identified. Again tones 2/3 were the most confusing contrast.

Broselow, Hurtig, and Ringen (1987) asked native speakers of English with no prior exposure to Mandarin to identify the tones presented in monosyllabic, bisyllabic, and trisyllabic words. In the singleton condition, detection of tone 4 was significantly better at 94% than detection of other three tones (i.e., 81% correct for tone 1, 78% for tone 3, and 67% for tone 2). As in Kiriloff (1969) and Wang et al. (1998, 1999), tones 2/3 were the most confusing pair.

Research with speakers of alphabetic languages discussed above focuses on the correlation between musical ability and onset/rhyme and phoneme awareness of a non-tonal language. Several studies of Chinese examine the effect of musical training on tone awareness for adult English speakers. Gottfried and Riester (2000) investigated the identification of the tone of Mandarin /l/+vowel syllables by native speakers of American English without knowledge of Mandarin. They observed that listeners with musical training were significantly better at tone identification than non-music listeners. Gottfried, Staby, and Ziemer (2004) employed a tone discrimination task which asked native speakers of American English to judge whether the tones were the same or different. The results confirmed the analysis of Gottfried and Riester (2000) in that listeners with more musical training had an advantage in perception of Mandarin tones.

Alexander et al. (2005) examined two groups of native speakers of American English with no knowledge of Mandarin, musicians who had eight or more years of continuous music lessons and non-musicians who had no more than three years of continuous music lesson. Five adult native speakers of Mandarin served as a control group. Participants were given tone identification and discrimination tasks. Mandarin speakers performed most accurately, with 97% correct responses in identification and 89% in discrimination respectively. Musicians averaged an 89% accuracy rate in identification and 87% in discrimination respectively. Non-musicians had the lowest accuracy rate, with 69% in identification and 71% in discrimination. A significant difference was found between the two American groups in terms of correct responses. Alexander et al. interpreted the results as demonstrating that “experience with music pitch processing may facilitate the processing of lexical pitch” (p. 3).

In S. Johnson (2005), respondents, who had no previous exposure to Mandarin, were divided into three groups: (1) a non-musical group with no musical training, (2) a musically inexperienced group with one to three years of musical training, and (3) a musically experienced group with three or more years of musical training. Testing materials were sound files of monosyllabic Mandarin words with four tones posted online in the form of an Internet survey. To complete the survey, the respondents were asked first to listen to one speaker's recording as training and then to listen to another speaker's recording to determine the tone of a stimulus. Analysis showed that the musically experienced group was 11% more accurate than the musically inexperienced group and 22.8% more accurate than the non-musical group. A t-test revealed a significant difference between the non-musical and musically experienced group, demonstrating the effect of musical training on the perception of lexical tones by speakers of a non-tonal language.

While little research to date has looked at the influence of talker variability on Mandarin speech perception, a few studies have addressed the role of fundamental frequency ($F0$) as a cue to speaker identity in perception of Mandarin tones. Leather (1983) tested Mandarin native speakers' identification of synthetic tone 1-tone 2 continua embedded in natural speech utterances produced by two male native speakers of Mandarin with different $F0$ ranges. The results indicated that talker-related $F0$ affected listeners' categorization of the stimuli as tone 1 or tone 2. Moore & Jongman (1997) examined native Mandarin speakers' perception of stimuli from a tone 2-3 continuum embedded in precursor phrases produced by two female speakers, one with a high *F0* and the other with a low *F0*. The results showed reliable shifts in identification as a function of the precursor, also supporting Leather's (1983) claim that perception of lexical tone is a talker-dependent process.

In perceiving speech, listeners not only deal with talker variability but also adjust for context-conditioned variability. There is a small body of research on the relationship between context and native and non-native Mandarin speakers' tone awareness. Xu (1994) compared native Mandarin speakers' identification of tones in two contexts: a compatible context in which surrounding tones had the same or similar values, e.g., a rising tone co-occurring with a falling tone as in *dàn bái zhì* 'protein' and a conflicting context in which surrounding tones had very different values, e.g., a rising tone with a level tone or a dipping tone as in *cōng yóu pĭng* 'fried garlic pancake' (p. 2241). Participants were asked to listen to a trisyllabic nonsense word in a carrier sentence and to choose their answer from four alternatives. The compatible context showed significantly greater accuracy (97%) than the conflicting context (88%).

Winitz (1981) tested monolingual, college-aged speakers of American English on the perception of Mandarin tones in different contexts. Participants were randomly assigned to one of the three conditions and asked to determine whether the tones of paired items presented in isolation, in disyllables, or in short sentences were the same or different. The results showed a significant effect for context. The error rate increased from isolated syllables to disyllables and to short sentences. In Broselow et al. (1987), native speakers of English with no prior exposure to Mandarin were asked to identify four tones in three conditions: monosyllabic, disyllabic, and tri-syllabic. In the single-tone condition, tone 4 was most accurately identified (94% correct) followed by tone 1 (81%), tone 3 (78%), and tone 2 (67%). In the disyllabic and tri-syllabic conditions, the accuracy rate decreased for all tones.

Lu (1993) tested native speakers of American English taking Elementary Chinese on the perception of Mandarin tones in three conditions. Participants were tested at the beginning of the semester after some words and sentences had been learned and at the end of the semester. The participants were asked to identify the tone of an isolated syllable and the tones of both syllables in a disyllable by writing down the corresponding tone numbers or marks on an answer sheet. They were also asked to identify all tones in a short sentence (e.g., *nǐ hǎo ma*? 'How are you') by choosing the one out of four answers. The participants performed significantly better in the second test than in the first test, indicating that instruction did enhance participants' tone awareness. The results also revealed that tone context had affected PA. Significant differences were observed between the three conditions in the first test, with an accuracy rate of 86% in the single-syllable condition, 65% in the two-syllable condition, and 50% in the short sentence condition, respectively. However, the differences disappeared on the second test. This study confirms the observations by Winitz (1981) and Broselow et al. (1987), suggesting that tone context affects tone awareness for early learners of a tonal language.

In summary, consistent with studies with speakers of alphabetic languages, studies with Chinese speakers and learners demonstrate that alphabetic experience enhances phoneme awareness for both children and adults and that alphabetic experience interacts with spoken language and L2 learning experience to facilitate Chinese children's PA. It has also been demonstrated that other factors such as musical ability, talker variability, and tone context affect tone awareness of Chinese speakers and learners. However, there has not been any research on the effect of item type or the perceptual difficulty with Mandarin onsets and rhymes by non-native speakers of Chinese. Neither has there been research on the effect of musical ability and talker variability on perceptual accuracy for Mandarin syllables, onsets, or rhymes by either native or non-native speakers of Chinese. What is lacking in previous research was considered in the present study.

CHAPTER 3 METHODOLOGY

Based on the phonology of Mandarin discussed in chapter 2, the present study assesses the effect of a variety of independent variables on the phonological awareness (PA) of four Mandarin units—syllable awareness, onset awareness, rhyme awareness, and tone awareness (see Figure 2)—and on overall PA by four groups of participants with different language backgrounds.

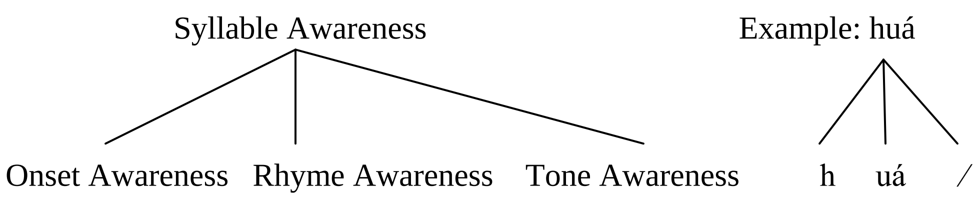


Figure 2. Phonological awareness in Mandarin.

The specific questions guiding this research are: (1) what independent variables contribute to patterns of difference across the native and nonnative speakers of Chinese? (2) are there error patterns among the different groups, and if so, how might they be explained? (3) what contributions do the results make to the growing literature in PA in general and Mandarin PA in specific? and (4) what implications do the results provide for teaching Mandarin to L2 learners?

Hypotheses

The following 30 hypotheses are tested in this research:

Overall PA

Hypothesis 1: There is no difference among tasks (syllable awareness, onset awareness, rhyme awareness, and tone awareness) with respect to the overall PA of Mandarin.

Hypothesis 2: There is no difference among the four participant groups with respect to the overall PA of Mandarin.

Hypothesis 3: Musical ability is not predictive of the overall PA of Mandarin.

Hypothesis 4: Sex of talker is not predictive of the overall PA of Mandarin.

Hypothesis 5: Participant groups' L2 learning experience is not predictive of the overall PA of Mandarin.

Task 1—Syllable Awareness

Hypothesis 6: There is no difference among the four participant groups with respect to the PA of Mandarin syllables.

Hypothesis 7: Musical ability is not predictive of the PA of Mandarin syllables.

Hypothesis 8: Sex of talker is not predictive of the PA of Mandarin syllables.

Hypothesis 9: Syllable position is not predictive of the PA of Mandarin syllables.

Hypothesis 10: Participant groups' L2 learning experience is not predictive of the PA of Mandarin syllables.

Task 2—Onset Awareness

Hypothesis 11: There is no difference among the four participant groups with respect to the PA of Mandarin onsets.

Hypothesis 12: Musical ability is not predictive of the PA of Mandarin onsets.

Hypothesis 13: Sex of talker is not predictive of the PA of Mandarin onsets.

Hypothesis 14: Item type is not predictive of English speakers' PA of Mandarin onsets.

Hypothesis 15: Participant groups' L2 learning experience is not predictive of the PA of Mandarin onsets.

Task 3—Rhyme Awareness

Hypothesis 16: There is no difference among the four participant groups with respect to the PA of Mandarin rhymes.

Hypothesis 17: Musical ability is not predictive of the PA of Mandarin rhymes.

Hypothesis 18: Sex of talker is not predictive of the PA of Mandarin rhymes.

Hypothesis 19: Item type is not predictive of English speakers' PA of Mandarin rhymes.

Hypothesis 20: Participant groups' L2 learning experience is not predictive of the PA of Mandarin rhymes.

Task 4—Tone Awareness

Hypothesis 21: There is no difference among the four participant groups with respect to the PA of Mandarin tones.

Hypothesis 22: Musical ability is not predictive of the PA of Mandarin tones.

Hypothesis 23: Sex of talker is not predictive of the PA of Mandarin tones.

Hypothesis 24: Tone context is not predictive of the PA of Mandarin tones.

Hypothesis 25: Participant groups' L2 learning experience is not predictive of the PA of Mandarin tones.

Spoken Language

Hypothesis 26: Typological distance from Mandarin is not predictive of the overall PA of Mandarin for Chinese speakers with *Pinyin* literacy (C1).

Hypothesis 27: Typological distance from Mandarin is not predictive of the PA of Mandarin syllables for Chinese speakers with *Pinyin* literacy (C1).

Hypothesis 28: Typological distance from Mandarin is not predictive of the PA of Mandarin onsets for Chinese speakers with *Pinyin* literacy (C1).

Hypothesis 29: Typological distance from Mandarin is not predictive of the PA of Mandarin rhymes for Chinese speakers with *Pinyin* literacy (C1).

Hypothesis 30: Typological distance from Mandarin is not predictive of the PA of Mandarin tones for Chinese speakers with *Pinyin* literacy (C1).

Participants

To test the effect of LANGUAGE GROUP, the present study compared four groups of research participants with distinct linguistic experience: (1) a Chinese group with *Pinyin* literacy (C1), (2) a Chinese group without *Pinyin* literacy (C2), (3) an English-speaking group learning Mandarin (E1), and (4) an English-speaking group not learning Mandarin (E2). No participant reported a history of hearing loss. Members of C1 and C2 were selected from the researcher's friends based on the researcher's knowledge of participants' linguistic experience. Members of E1 were from a Basic Chinese class at Auburn University, and those of E2 from an English Composition class at Auburn university. Members of all groups volunteered to take part in this study. To ascertain that participants met the requirements for a specific group, the researcher asked each of them whether they had *Pinyin* literacy or knowledge before recruiting them. A questionnaire was also administered (see Appendix A for the Chinese version and Appendix B for the English version) to each group at the beginning of the test. The questionnaire enabled the researcher to access all participants' exposure to second languages and their musical training as well as Chinese participants' first Chinese language (or dialect) and their experience with other Chinese languages (or dialects).

The first Chinese group with *Pinyin* literacy (C1) included 10 Chinese-English bilingual students aged 22-34 (mean age = 25). All members of this group were graduate students at Auburn University and have lived in the U.S. for one to five years. All members of this group also speak a variety of Chinese other than Mandarin as their first language but are fluent in Mandarin. Some participants are able to speak more than two varieties of Chinese. To test the effect of SPOKEN LANGUAGE, this group was further divided into two subgroups according to their response to the questionnaire: those whose first variety and Mandarin are both dialects of Northern Speech and those whose first variety is another Chinese language. In addition to their Chinese bilingualism, all participants in this group had studied English for at least 12 years and were fluent in English.

The second Chinese group without *Pinyin* literacy (C2) was comprised of 10 Chinese aged 22-38 (mean age = 28) who also speak a Chinese variety other than Mandarin as their first language and are fluent in Mandarin. They also had limited competence in English although they had been in the U.S. for between five and ten years.

All lacked knowledge of spelling-pronunciation correspondences in English. These participants were not associated with Auburn University but lived nearby.

The first English-speaking group (E1) consisted of 10 undergraduate students at Auburn University aged 19-22 (mean age = 20) who were learning Mandarin as a foreign language. All participants had taken Basic Chinese I in fall 2007, and at the time of this study were taking a Basic Chinese II class offered by the Department of Foreign Languages and Literatures. They had some knowledge of *Pinyin*. All members of this group are native speakers of American English, and some had learning experiences with at least one other foreign language such as Spanish or French. Before taking Chinese I, none of them had previous knowledge of Mandarin.

The second English-speaking group (E2) was also composed of 10 undergraduate students at Auburn University aged 18-20 (mean age = 19). They had no knowledge of Mandarin or *Pinyin*. Like E1 participants, members of this group are native speakers of American English; most of them had learned a foreign language such as Spanish or French. Members of this group were rewarded with course credit to take part in the study while the other three groups were not compensated for their participation.

Testing Materials

A demographic questionnaire was given to all participants. A Chinese version was given to native Chinese speakers; an English version was given to native English speakers. There was one minor difference between these two versions. The Chinese version asked for participants' learning experience of not only foreign languages but also Chinese languages (see Appendix A for details).

A battery of four tasks based on four criteria created by the researcher was administered to all participants. The memory demand and difficulty level of the tasks were minimized so that the tasks were suitable for both Chinese and American participants. The tasks were constructed to assess different levels of PA based on phonological features of Mandarin. Each of the four tasks assessed awareness of a specific phonological unit: syllable awareness, onset awareness, rhyme awareness, and tone awareness. To control for frequency effects, all items were Mandarin non-words. Tone sandhi (Chao, 1948, 1968) was controlled for by eliminating tone sequences containing tone 3.

Stimulus items were recorded by two native speakers of Mandarin, half of the items in each task by a female and half by a male, to examine the effect of SEX OF TALKER. The recording was made with Audacity software which digitized the recorded items with a sampling rate of 44100 Hz. The digitized items were stored on a CD as mp3 files and grouped into four blocks, one for each of the four PA tasks. Each block started with a short announcement in Mandarin for the Chinese groups and in English for the English-speaking groups— "We are going to do this task. Are you ready? Let's go." This was followed by a 5-second pause. Immediately after the pause, the first item in the first set was presented. A 250-msecond pause followed the acoustic offset of the first item. The second item was then presented. Participants were allowed five seconds to respond after the presentation of each set of items. At the end of each block, there was a short announcement in either Mandarin or English—"This task is over. You can relax a little bit."

Task 1—syllable same-different. The first task asked participants to determine if 20 pairs of syllables were the same or different. All stimuli were two-syllable non-words. Since the level contour of tone 1 and the falling and rising contour of tone 3 make the clearest the boundary between two syllables, the first syllable in all items had tone 1, and the second syllable in all items had tone 3. To test the effect of SYLLABLE POSITION, participants listened to the first ten pairs and judged whether a pair shared the first syllable (e.g., ***lō****gǐ*-***lō****tǒ*). Then they listened to the other ten pairs and determined whether a pair shared the second syllable (e.g., *gī**lǒ**-tō**lǒ***).

Task 2—onset oddity. As in Chen et al. (2004), participants listened to 20 sets of three Mandarin monosyllabic non-words with the same tone and judged which one had a different onset. For example, among *bōu*, *fāo,* and *fiū*, *bōu* is the odd one. There were four groups of five items in which all items in each set shared one of four tones. The placement of the odd onset was randomized. To test the effect of ITEM TYPE, target items in ten sets contained Mandarin onsets similar to those in English, [f], [b], and [t]; those in the other ten sets contained onsets existing only in Mandarin, [tʂʰ], [tɕʰ], and [ɕ].

Task 3—rhyme oddity. This task paralleled the onset oddity task. Participants listened to 20 sets of three monosyllabic non-words with the same tone and judged which one had a different rhyme. For example, among *qōu*, *qō,* and *xō*, the odd rhyme is *qōu*. There were four groups of five sets in which all items shared one of four tones. To test the effect of ITEM TYPE, items in ten sets had Mandarin rhymes similar to those in English, [aʊ], [o], and [aɪ]; those in the other ten sets had rhymes existing only in Mandarin, [y], [yn], and [ia].

Task 4—tone identification. To test the effect of TONE CONTEXT, this task was comprised of two parts, each of which had 24 sets of items. Part 1 assessed the identification of tones in monosyllabic non-words. Two monosyllabic words *to* and *lo* were repeated 12 times in random order, three times in each of the four tones. In this part of the task, participants first listened to a word and then identified its tone. Part 2 measured the identification of tones in disyllabic non-words. Two disyllables *logi* and *togi* were used. Each was repeated 12 times in random order. All the possible two-syllable tone combinations, excluding those containing tone 3 (to avoid sandhi effects), were represented. In this part, participants listened to a disyllable (e.g., *lógǐ*) and determined the tone of the first syllable.

Procedure

All participants in each language group except for C2 were tested simultaneously in a computerized classroom. The researcher spoke Mandarin to C1 and English to E1 and E2 participants. To start, an answer sheet with a questionnaire (see Appendix A for the Chinese version and Appendix B for the English version) was handed out to participants. Participants were instructed to answer those questions first. Then the four tasks were administered. To minimize fatigue and increase concentration, there was a five-minute break between tasks. The entire testing session lasted approximately 40 minutes.

Each task began with demonstration sets. There were two demonstration sets for the syllable awareness task. In the first set, the researcher said a pair of Mandarin disyllables and then explained to participants which syllable the two items shared. In the second set, the items did not have a shared syllable. The demonstration was followed by six practice sets, four for a *yes* response and two for a *no* response. During practice, the researcher said each pair and then asked participants to give a response. Feedback was provided after they responded. Before the experimental task, participants were reminded which part of the word to monitor and how to indicate responses. Then the researcher played the CD with test items (see Appendix C) using the Windows Media Player on the computer in the classroom. Participants listened to each of 20 pairs presented via two speakers installed in the classroom and marked a *yes* or *no* choice on their answer sheet numbered from 1) to 20) with a blank next to the *yes* and *no* choices. The second task followed the first one.

The procedures for the other three tasks paralleled that of Task 1. In the two demonstration sets for the onset and rhyme awareness tasks, the researcher spoke a set of three real words and explained that one word did not share the onset or rhyme with the other two words. Four practice sets followed. In the experimental tasks, participants listened to sets of three words and indicated which one was the odd onset or rhyme by marking the answer sheet. The answer options were 1, 2, and 3 for the onset and rhyme awareness tasks.

For both parts of the tone awareness task, there were four demonstration sets, one for each tone, and eight practice sets, two for each tone. In the demonstration sets, the researcher uttered a Mandarin monosyllable in Part I or a disyllable in Part II and told participants which tone the monosyllable or the first syllable of the disyllable had. There were eight practice sets because it was anticipated that this task would be more difficult than the other three, especially for the English-speaking groups. In the experimental task, participants listened to a monosyllable in Part I or a disyllable in Part II and identified the tone of the monosyllable or of the first syllable of the disyllable by marking the answer sheet. The answer options were 1, 2, 3, and 4 for the tone identification task.

Participants in C2 were tested individually at a time and location chosen by each participant because they were not members of the University community and might not feel comfortable in a university setting. Mandarin was spoken to them, and the answer sheet was in Chinese. The procedure was similar to those for the other three groups with respect to the order of answering the questionnaire, demonstration, practice, and experiment. Participants, without earphones, listened to experimental stimuli stored on the same CD used with the other three groups. The same files were played using the Windows Media Player on the researcher's Dell notebook. Participants were instructed to provide their responses on identical answer sheets after listening to each set of stimuli in all tasks.

Data Coding

This study examined the relationship between a dependent variable—overall PA and the PA of four components (i.e., syllables, onsets, rhymes, and tones) and nine independent variables.

The dependent variable coded for accuracy. Answers to the four PA tasks (i.e., the syllable, onset, rhyme, and tone awareness tasks) were coded as either correct or incorrect.

In keeping with practice in quantitative sociolinguistics, in the present study, independent variables are identified as factor groups. Not all factor groups are relevant to each task. Those factor groups and the tasks they are hypothesized to influence appear below in Table 5:

Table 5

Independent Factor Groups Relevant to Overall PA and Each Task

Overall PA	Task 1: Syllable Awareness	Task 2: Onset Awareness	Task 3: Rhyme Awareness	Task 4: Tone Awareness
Task, Language group, Sex of talker, Musical ability, L2 learning experience	Language group, Sex of talker, Musical ability, Syllable position, L2 learning experience	Language group, Sex of talker, Musical ability, Item type, L2 learning experience	Language group, Sex of talker, Musical ability, Item type, L2 learning experience	Language group, Sex of talker, Musical ability, Tone context, L2 learning experience

The coding of factor groups and the factors that each of them contains are detailed below:

1. Factor group one coded for TASK. Its factors include Task 1—syllable awareness, Task 2—onset awareness, Task 3—rhyme awareness, and Task 4—tone awareness.
2. Factor group two coded for LANGUAGE GROUP. The first group, C1, was composed of Chinese speakers with *Pinyin* literacy. The second group, C2, was composed of Chinese speakers without *Pinyin* literacy. The third group, E1, was composed of English speakers with some knowledge of Mandarin and *Pinyin*. The fourth group, E2, was composed of English speakers without such knowledge. The C1, E1, and E2 groups all had alphabetic literacy.
3. Factor group three coded for MUSICAL ABILITY. There were three factors. Members of the non-music group had no musical training at all. The inexperienced music group was composed of those with less than ten years

musical training. The experienced music group had participants with more than ten years musical training.

4. Factor group four coded for SEX OF TALKER. Answers were coded as items pronounced by a male or female native speaker of Mandarin.
5. Factor group five coded for L2 LEARNING EXPERIENCE. Each of the four language groups was divided into two subgroups: (1) one with L2 experience and (2) one with no L2 experience.
6. Factor group six, which was relevant only to the syllable awareness task, coded for SYLLABLE POSITION: whether a syllable was the first or final syllable of a disyllable. This factor group is new in the present study and has never been examined by previous research on Mandarin PA.
7. Factor group seven, which was relevant only to the onset and rhyme awareness tasks, coded for ITEM TYPE: whether test items contained segments that were present or absent in English.
8. Factor group eight, which was relevant only to the tone awareness task, coded for TONE CONTEXT: whether the tone was in a monosyllable or in the first syllable of a disyllable.
9. The last factor group, coding for SPOKEN LANGUAGE, was relevant only to C1. Although members of both C1 and C2 speak a Chinese language or dialect other than Mandarin as their first language (spoken language), variation was found only in C1 because members of C2 speak the same first language. Members of C1 were coded as Group A whose spoken language is a dialect that like Mandarin, belongs to Northern Speech or as Group B whose spoken

language is one of other Chinese languages. The typological distance between Group A's spoken language and Mandarin is smaller than that between Group B's and Mandarin. Therefore, this factor group was tested to examine the effect of this difference on C1 participants' overall PA in Mandarin and the PA of Mandarin syllables, onsets, rhymes, and tones.

Data Analysis

The present study differs from traditional sociolinguistic analyses in two ways. Sociolinguistic investigation typically focuses on production data—what people say. The present study analyzes perception data. Specifically, the study seeks to determine the extent to which characteristics of linguistic variables (e.g., linguistic experience, item type) and non-linguistic variables (e.g., musical ability, sex of talker) correlate with awareness of Mandarin phonological units. Additionally, while many quantitative sociolinguistic studies use Variable Rule Analysis (cf. Cedergren & Sankoff, 1974; Rand & Sankoff, 1990), the present study uses a comparable commercially available dos application, JMP Statistical Discovery.™ From SAS, version 8, both for its more conservative analysis (Sabino, Diamond, & Head, 2004) and for its flexibility and user friendliness.

The present study employs two methods of analysis widely used in quantitative sociolinguistics: logistic regression (Taglimonte, 2006) and Chi Square. Logistic regression quantifies the simultaneous contributions of a number of independent variables and indicates how much of the observable variation in the dependent variable can be attributed to the independent variables. Chi Square evaluates the relationship between a dependent variable and an independent variable. It determines whether differences between observed and expected frequencies are due to the influence of the independent variables or whether they should be attributed to sampling fluctuation.

Analysis in the present study proceeded in the following manner. An initial logistic regression was run on the data with those factor groups relevant to overall PA or the PA of each component (see Table 5) to identify which factor groups were significant. (The factor group, L2 LEARNING EXPERIENCE, had to be dropped because most of the participants had L2 learning experience.) For significant factor groups with more than two factors, pair-wise Chi Squares were calculated to determine whether the factors within the group differed significantly from each other, and those factors which shared one or more attributes were combined into a compound factor for the final logistic regression. For example, members of language groups C1, E1, and E2 shared alphabetic literacy; in contrast, members of C2 could not read an alphabetic script. Thus, when distributions of response for C1, E1, and E2 did not differ significantly from each other, but differed significantly from the performance of C2, the responses for C1, E1, and E2 were recoded as a single factor called alphabetic literacy. When recodings were complete for all significant factor groups, the final logistic regression was run with only the recoded, significant factors. In this study, logistic regression was also used to examine the effect of the factor group, SPOKEN LANGUAGE, on the overall PA and the PA of the four components for the Chinese group with *Pinyin* literacy (C1).

This study also made error analyses to investigate error patterns of the tone awareness task. The first method of analysis examined different language groups' percent correct identification for each tone in both monosyllables and disyllables. The second method, analysis of tone confusions, compared the number of errors made by different language groups for each tone pair in both monosyllables and disyllables. For example, the number of errors for the tone pair 1 and 2 is the sum of misperceptions for tone 1 as tone 2 and for tone 2 as tone 1.

CHAPTER 4 ANALYSIS OF DATA

This chapter describes the analyses performed on the data for the four tasks. Each task is associated with a data set composed of responses from the study's 40 research participants. The data for Task 1—Syllable Awareness—contained responses to 20 questions for a total of 800 responses (40 x 20). The data for Task 2—Onset Awareness—contained responses to 20 questions for a total of 800 responses (40 x 20). The data for Task 3—Rhyme Awareness—contained responses from 20 questions for a total of 800 responses (40 x 20). The data for Task 4—Tone Awareness—contained responses from 48 questions for a total of 1920 responses (40 x 48). The data set for overall PA combined the data sets for each of the four tasks for a total of 4320 responses (800+800+800+1920).

Four types of results are given. First, analysis of overall PA is presented. Second, analyses of each of the four components of PA (i.e., syllables, onsets, rhyme, and tones) are displayed. Third, analysis of the effect of SPOKEN LANGUAGE for the Chinese group with *Pinyin* literacy (C1) is given. Next, error analyses conducted on the responses to the tone identification task are presented. Finally, there is a summary of the results of the study.

Analysis of Overall PA

In the initial logistic regression of the full data set, as Figure 3 shows, the factor groups TASK ($p < .0001$) and LANGUAGE GROUP ($p < .0001$) were identified as significantly correlated with participants' overall performance. The factor groups MUSICAL ABILITY and SEX OF TALKER did not significantly contribute to participants' ability to correctly identify Mandarin phonological units.

Nominal Logistic Fit for accuracy

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	225.1289	9	450.2577	<.0001
RSquare (U)		0.0947		

Effect Wald Tests

Source	Nparm	DF	Wald ChiSquare	Prob>ChiSq
task	3	3	172.400514	0.0001
language group	3	3	125.326819	0.0001
sex of talker	1	1	0.99828352	0.2908
musical ability	2	2	3.17058139	0.2840

Figure 3. The initial logistic regression of overall PA in Mandarin.

Table 6 shows the distribution of responses for the factor group TASK. Follow-up pair-wise Chi Square analyses indicated that performance on syllable awareness was the best at 96% correct and that performance on onset awareness was the least correct at 66% correct. There was no significant difference between rhyme and tone awareness. Since rhyme is the subsyllabic unit that carries tone, the two factors were combined for a final logistic regression of overall performance.

Table 6

Analysis of Accuracy by Task for Overall PA

Count Row %	Correct	Incorrect	Total
Syllable awareness	767 95.88	33 4.13	800
Onset awareness	527 65.88	273 34.13	800
Rhyme awareness	581 72.63	219 27.38	800
Tone awareness	1410 73.42	510 26.58	1920
	3285	1035	4320

Significant at less than .0001

The distribution of responses for the factor group LANGUAGE GROUP is shown in Table 7. Pair-wise Chi Square between each of the language groups indicated that the Chinese group with *Pinyin* literacy (C1) performed significantly better than the other three groups. Their performance was significantly better than the Chinese group without *Pinyin* literacy (C2) at $p < .0001$. The English-speaking group learning Mandarin (E1) performed significantly better than both C2 ($p < .0001$) and their English-speaking counterparts who were not learning Mandarin (E2) ($p < .0001$). The performance of C2 and E2 was not significantly different from each other. The two groups shared little beyond their performance on the PA tasks; therefore, they were retained as separate in the final logistic regression.

Table 7

Analysis of Accuracy by Language Group for Overall PA

Count Row %	Correct	Incorrect	Total
C1 (Chinese with *Pinyin* literacy)	936 86.67	144 13.33	1080
C2 (Chinese without *Pinyin* literacy)	747 69.17	333 30.83	1080
E1 (English speakers learning Mandarin)	864 80.00	216 20.00	1080
E2 (English speakers not learning Mandarin)	738 68.33	342 31.67	1080
	3285	1035	4320

Significant at less than .0001

As Figure 4 shows, the final logistic regression with the rhyme and tone tasks combined revealed results similar to those in the initial logistic regression. The factor groups TASK ($p < .0001$) and LANGUAGE GROUP ($p < .0001$) were significant while MUSICAL ABILITY and SEX OF TALKER were not.

Nominal Logistic Fit for accuracy

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	228.7008	16	457.4016	<.0001*
RSquare (U)		0.0958		

Effect Likelihood Ratio Tests

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
task	4	4	302.215067	<.0001*
language group	6	6	136.924298	<.0001*
sex of talker	2	2	2.48488487	0.2887
musical ability	4	4	5.08341819	0.2788

Figure 4. The final logistic regression of overall PA in Mandarin.

Analysis of Task 1—Syllable Awareness

In the initial logistic regression of the responses to the syllable awareness task, as Figure 5 shows, LANGUAGE GROUP ($p < .0002$) and SYLLABLE POSITION ($p < .05$)

were significant factor groups. MUSICAL ABILITY and SEX OF TALKER were not significant.

Nominal Logistic Fit for accuracy

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
RSquare (U)		0.0962		

Effect Wald Tests

Source	Nparm	DF	Wald ChiSquare	Prob>ChiSq
syllable position	1	1	3.78476318	0.0455
language group	3	3	10.7874489	0.0002
sex of talker	1	1	0.81105405	0.3652
musical ability	2	2	1.22309577	0.5214

Figure 5. The initial logistic regression of the PA of Mandarin syllables.

Table 8 shows the distribution of responses for the factor group LANGUAGE GROUP for this task. All four language groups attained close-to-ceiling performance with an accuracy rate above 90%. Chi Square indicated that the Chinese group without *Pinyin* literacy (C2) performed significantly worse than the other groups which did not differ significantly from each other.

Table 8

Analysis of Accuracy by Language Group for Syllable Awareness

Count Row %	Correct	Incorrect	Total
C1 (Chinese with *Pinyin* literacy)	199 99.50	1 0.50	200
C2 (Chinese without *Pinyin* literacy)	182 91.00	18 9.00	200
E1 (English speakers learning Mandarin)	192 96.00	8 4.00	200
E2 (English speakers not learning Mandarin)	194 97.00	6 3.00	200
	767	33	800

Significant at less than .0002

Because C1, E1, and E2 shared alphabetic literacy, they were combined into a new factor and were opposed to a non-alphabetic factor (C2) for another Chi Square analysis. This recoding changed the factor group, LANGUAGE GROUP, in the initial Chi Square to a new factor group, ALPHABETIC LITERACY, and increased the significance from $p < .0002$ for LANGUAGE GROUP to $p < .0001$ for ALPHABETIC LITERACY. After recoding, the new alphabetic group attained a significantly better performance (97% correct) than the non-alphabetic group (91% correct).

Table 9 shows the distribution of responses for the factor group SYLLABLE POSITION for this task. The results indicated that participants performed significantly better when determining if a pair of disyllables shared the final syllable than whether they shared the first syllable.

Table 9

Analysis of Accuracy by Syllable Position for Syllable Awareness

Count Row %	Correct	Incorrect	Total
First syllable	378 94.50	22 5.50	400
Final syllable	389 97.25	11 2.75	400
	767	33	800

Significant at less than .05

The final logistic regression with the recoded factor group (see Figure 6), ALPHABETIC LITERACY, showed that ALPHABETIC LITERACY ($p < .0002$) and SYLLABLE POSITION ($p < .05$) were significant. The factor groups, MUSICAL ABILITY and SEX OF TALKER, were not significant.

Nominal Logistic Fit for accuracy

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	10.28034	5	20.56069	0.0010
RSquare (U)		0.0748		

Effect Wald Tests

Source	Nparm	DF	Wald ChiSquare	Prob>ChiSq
syllable position	1	1	3.76854614	0.0459
Language group→ alphabetic literacy	1	1	9.78206319	0.0002
sex of talker	1	1	0.8073511	0.3663
musical ability	2	2	1.76385371	0.3605

Figure 6. The final logistic regression of the PA of Mandarin syllables.

Analysis of Task 2—Onset Awareness

In the initial logistic regression of the responses to the onset awareness task, as Figure 7 shows, LANGUAGE GROUP ($p < .0001$) and ITEM TYPE ($p < .0001$) were significant factor groups. MUSICAL ABILITY and SEX OF TALKER were not found to be significant.

Nominal Logistic Fit for accuracy for onset awareness

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	31.58030	7	63.1606	<.0001
RSquare (U)		0.0615		

Effect Wald Tests

Source	Nparm	DF	Wald ChiSquare	Prob>ChiSq
language group	3	3	28.8908109	0.0001
sex of talker	1	1	4.41191773	0.0571
item type	1	1	36.5305863	0.0001
musical ability	2	2	1.39351113	0.4962

Figure 7. The initial logistic regression of the PA of Mandarin onsets.

Table 10 shows the distribution of responses for the factor group LANGUAGE GROUP for this task. Chi Square indicated that the Chinese group without *Pinyin* literacy

(C2), at 56% correct, was significantly inferior to the other three groups that did not differ significantly from each other. For this reason, as in the analyses of the data for the syllable awareness task, these three groups were combined into an alphabetic factor and were opposed to a non-alphabetic factor (C2) for another Chi Square analysis. This recoding changed the factor group, LANGUAGE GROUP, in the initial Chi Square to a new factor group, ALPHABETIC LITERACY, and substantially increased the significance from $p < .005$ for LANGUAGE GROUP to $p < .0007$ for ALPHABETIC LITERACY. After recoding, the alphabetic group attained an accuracy rate of 69% compared with the non-alphabetic group's rate of 56%.

Table 10

Analysis of Accuracy by Language Group for Onset Awareness

Count Row %	Correct	Incorrect	Total
C1 (Chinese with *Pinyin* literacy)	133 66.50	67 33.50	200
C2 (Chinese without *Pinyin* literacy)	112 56.00	88 44.00	200
E1 (English speakers learning Mandarin)	143 71.50	57 28.50	200
E2 (English speakers not learning Mandarin)	139 69.50	61 30.50	200
	527	273	800

Significant at less than .005

As Table 11 shows, all participants performed significantly better on items containing onsets present in English (69% correct) than on items containing onsets absent in English (56% correct).

Table 11

Analysis of Accuracy by Item Type for All Participants' Onset Awareness

Count Row %	Correct	Incorrect	Total
Items containing onsets present in English	416 69.33	184 30.67	600
Items containing onsets absent in English	111 55.50	89 44.50	200
	527	273	800

Significant at less than .0004

All Mandarin items were familiar to the two Chinese groups. Additional Chi Square analyses were conducted to examine the effect of ITEM TYPE on the two English-speaking groups. As Table 12 shows, this factor group was highly significant for English speakers ($p < .0001$). The English-speaking groups accurately identified 86% of the items containing onsets present in English as opposed to only 56% of the items containing onsets absent in English.

Table 12

Analysis of Accuracy by Item Type for English Speakers' Onset Awareness

Count Row %	Correct	Incorrect	Total
Items containing onsets present in English	171 85.50	29 14.50	200
Items containing onsets absent in English	111 55.50	89 44.50	200
	282	118	400

Significant at less than .0001

To examine whether E1, with some knowledge of Mandarin, differed from E2 with no such knowledge, Chi Square analyses were performed for the two groups. As shown in Tables 13 and 14, the two groups did not differ from each other despite E1's learning experience with Mandarin in identification of items containing onsets either present or absent in English.

Table 13

Analysis of Accuracy by English-Speaking Group for Items Containing Onsets Present in English

Count Row %	Correct	Incorrect	Total
E1 (English speakers learning Mandarin)	88 88.00	12 12.00	100
E2 (English speakers not learning Mandarin)	83 83.00	17 17.00	100
	171	29	200

Not significant

Table 14

Analysis of Accuracy by English-Speaking Group for Items Containing Onsets Absent in English

Count Row %	Correct	Incorrect	Total
E1 (English speakers learning Mandarin)	55 55.00	45 45.00	100
E2 (English speakers not learning Mandarin)	56 56.00	44 44.00	100
	119	89	200

Not significant

The final logistic regression with the recoded factor group (see Figure 8), ALPHABETIC LITERACY, indicated that the factor groups ITEM TYPE ($p < .0001$), ALPHABETIC LITERACY ($p < .0007$), and SEX OF TALKER ($p < .04$) significantly contributed to participants' ability to correctly identify Mandarin onsets. MUSICAL ABILITY was not found to significantly influence onset awareness.

Nominal Logistic Fit for accuracy
Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	26.67423	6	53.34847	<.0001*
RSquare (U)		0.0519		

Effect Likelihood Ratio Tests

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
language group→ alphabetic literacy	1	1	11.5877311	0.0007*
sex of talker	1	1	4.08426613	0.0433*
Item type	2	2	32.5874448	<.0001*
musical ability	2	2	1.03857554	0.5949

Figure 8. The final logistic regression of the PA of Mandarin onsets.

Analysis of Task 3—Rhyme Awareness

In the logistic regression of the responses to the rhyme awareness task, as Figure 9 shows, SEX OF TALKER ($p < .0001$), ITEM TYPE ($p < .0005$), and LANGUAGE GROUP ($p < .005$) were identified as significant factor groups. MUSICAL ABILITY was not significant.

Nominal Logistic Fit for accuracy
Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	46.87770	7	93.7554	<.0001
RSquare (U)		0.0998		

Effect Wald Tests

Source	Nparm	DF	Wald ChiSquare	Prob>ChiSq
language group	3	3	12.2803472	0.0047
sex of talker	1	1	39.7650901	0.0001
Item type	1	1	11.3966753	0.0005
musical ability	2	2	2.18421649	0.3374

Figure 9. The logistic regression of the PA of Mandarin rhymes.

Table 15 shows the distribution of responses for the factor group LANGUAGE GROUP for this task. Chi Square indicated that the English-speaking group learning Mandarin (E1) attained significantly better performance than the other groups at 85%

correct while the Chinese group without *Pinyin* literacy (C2) was significantly worse than the other groups at only 60% correct. The Chinese group with *Pinyin* literacy (C1) was not significantly different from the English-speaking group not learning Mandarin (E2).

Table 15

Analysis of Accuracy by Language Group for Rhyme Awareness

Count Row %	Correct	Incorrect	Total
C1 (Chinese with *Pinyin* literacy)	142 71.00	58 29.00	200
C2 (Chinese without *Pinyin* literacy)	120 60.00	80 40.00	200
E1 (English speakers learning Mandarin)	169 84.50	31 15.50	200
E2 (English speakers not learning Mandarin)	150 75.00	50 25.00	200
	581	219	800

Significant at less than .0001

The factor group ITEM TYPE also had a significant effect on rhyme awareness ($p < .0001$). However, the result was opposite of that for the onset awareness task. As Table 16 shows, all participants scored significantly better on items containing rhymes absent in English (88% correct) than items containing rhymes present in English (68% correct).

Table 16

Analysis of Accuracy by Item Type for All Participants' Rhyme Awareness

Count Row %	Correct	Incorrect	Total
Items containing rhymes present in English	405 67.50	195 32.50	600
Items containing rhymes absent in English	176 88.00	24 12.00	200
	581	219	800

Significant at less than .0001

Since all Mandarin items were familiar to the two Chinese groups, additional Chi Square analyses were conducted to examine the effect of ITEM TYPE on the two English-speaking groups. Table 17 shows that items containing rhymes absent in English posed significantly less difficulty (88% correct) than items containing rhymes present in English (72% correct).

Table 17

Analysis of Accuracy by Item Type for English Speakers' Rhyme Awareness

Count Row %	Correct	Incorrect	Total
Items containing rhymes present in English	143 71.50	57 28.50	200
Items containing rhymes absent in English	176 88.00	24 12.00	200
	319	81	400

Significant at less than .0001

To examine whether E1, with some knowledge of Mandarin, differed from E2 with no such knowledge, Chi Square analyses were performed for the two groups. As Tables 18 and 19 indicate, E1 differed significantly from E2 in identification of items containing rhymes absent in English at $p < .001$, but not in identification of items containing rhymes present in English.

Table 18

Analysis of Accuracy by English-Speaking Group for Items Containing Rhymes Present in English

Count Row %	Correct	Incorrect	Total
E1 (English speakers learning Mandarin)	73 73.00	27 27.00	100
E2 (English speakers not learning Mandarin)	70 70.00	30 30.00	100
	143	57	200

Not significant

Table 19

Analysis of Accuracy by English-Speaking Group for Items Containing Rhymes Absent in English

Count Row %	Correct	Incorrect	Total
E1 (English speakers learning Mandarin)	96 96.00	4 4.00	100
E2 (English speakers not learning Mandarin)	80 80.00	20 20.00	100
	176	24	200

Significant at less than 0.001

As Table 20 shows, all participants identified the items pronounced by a native male speaker of Mandarin (83% correct) significantly more accurately than the items pronounced by a native female speaker of Mandarin (62% correct).

Table 20

Analysis of Accuracy by Sex of Talker for Rhyme Awareness

Count Row %	Correct	Incorrect	Total
Items pronounced by a female speaker	248 62.00	152 38.00	400
Items pronounced by a male speaker	333 83.25	67 16.75	400
	581	219	800

Significant at less than .0001

Analysis of Task 4—Tone Awareness

In the logistic regression of the responses to the tone awareness task, as Figure 10 shows, LANGUAGE GROUP ($p < .0001$) and TONE CONTEXT ($p < .0001$) were highly significant factor groups. MUSICAL ABILITY and SEX OF TALKER were not significant.

Nominal Logistic Fit for accuracy

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	148.9493	7	297.8987	<.0001
RSquare (U)		0.1341		

Effect Wald Tests

Source	Nparm	DF	Wald ChiSquare	Prob>ChiSq
language group	3	3	169.360445	0.0001
sex of talker	1	1	0.60454173	0.3748
tone context	1	1	17.5101156	0.0001
musical ability	2	2	5.72595734	0.1132

Figure 10. The logistic regression of the PA of Mandarin tones.

Table 21 shows the distribution of responses for the factor group LANGUAGE GROUP for this task. The Chinese group with *Pinyin* literacy (C1) scored better (96% correct) than the other groups while the English-speaking group not learning Mandarin (E2) performed worse (53%) than the others. The English-speaking group learning Mandarin (E1) outperformed the Chinese group without *Pinyin* literacy (C2) at 75% correct vs. 69% correct, but Chi Square indicated that the difference was not significant.

Table 21

Analysis Of Accuracy by Language Group for Tone Awareness

Count Row %	Correct	Incorrect	Total
C1 (Chinese with *Pinyin* literacy)	462 96.24	18 3.76	480
C2 (Chinese without *Pinyin* literacy)	333 69.38	147 30.63	480
E1 (English speakers learning Mandarin)	360 75.00	120 25.00	480
E2 (English speakers not learning Mandarin)	255 53.13	225 46.88	480
	1410	510	1920

Significant at less than .0001

Table 22 shows that participants had a significantly better performance when identifying the tone of a monosyllable (77% correct) than when identifying the tone of the first syllable of a disyllable (69% correct).

Table 22

Analysis of Accuracy by Tone Context for Tone Awareness

Count Row %	Correct	Incorrect	Total
Tone in disyllables	667 69.45	293 30.55	960
Tone in monosyllables	743 77.40	217 22.60	960
	1410	510	1920

Significant at less than .0001

Chi Square Analyses were also conducted to test the effect of TONE CONTEXT on each group. This factor group did not contribute significantly to the performance of either C1 or C2. As Table 23 shows, TONE CONTEXT had a significant effect for E1 ($p < .0003$). This group attained superior performance on tones in monosyllables (82% correct) than on tones in disyllables (68% correct). E2 ($p < .0007$) performed similarly with 61% correctly identifying tones in monosyllables and 45% correctly in disyllables, as Table 24 shows.

Table 23

Analysis of Accuracy by Tone Context for E1

Count Row %	Correct	Incorrect	Total
Tones in disyllables	163 67.92	77 32.08	240
Tones in monosyllables	197 82.08	43 17.92	240
	360	120	480

Significant at less than .0003

Table 24

Analysis of Accuracy by Tone Context for E2

Count Row %	Correct	Incorrect	Total
Tones in disyllables	109 45.42	131 54.58	240
Tones in monosyllables	146 60.83	94 39.17	240
	255	225	480

Significant at less than .0007

Since, contrary to expectations, MUSICAL ABILITY was not significant in all analyses, Chi Square analysis of music by language group was conducted for possible causes. Table 25 reveals that the small number of the experienced music group may have led to this result. The two Chinese groups had no participants who belonged to the experienced music group, and all participants in C2 had no musical training.

Table 25

Analysis of Music by Language Group for Tone Awareness

Count Row %	Non-music group	Inexperienced music group	Experienced music group	Total
C1 (Chinese with *Pinyin* literacy)	240 50.00	240 50.00	0 0.00	480
C2 (Chinese without *Pinyin* literacy)	480 100.00	0 0.00	0 0.00	480
E1 (English speakers learning Mandarin)	144 30.00	192 40.00	144 30.00	480
E2 (English speakers not learning Mandarin)	144 30.00	188 39.17	148 30.83	480
	1008	620	292	1920

Analysis of SPOKEN LANGUAGE for the Chinese Group with *Pinyin* Literacy (C1)

In the logistic regression of C1's overall performance, as Figure 11 shows, only the factor group TASK significantly conditioned this group's overall performance at *p* < .0001. Other factor groups, SPOKEN LANGUAGE, SEX OF TALKER, and MUSICAL ABILITY, were not significant. In the logistic regression of C1's responses to each task, as Figures 12-15 show, the factor group SPOKEN LANGUAGE was not found to significantly affect any of the four tasks.

Nominal Logistic Fit for accuracy

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	93.15656	6	186.3131	<.0001
RSquare (U)		0.2197		

Effect Wald Tests

Source	Nparm	DF	Wald ChiSquare	Prob>ChiSq
task	3	3	104.477669	0.0000
sex of talker	1	1	0.34144302	0.5590
musical ability	1	1	0.04120702	0.8391
spoken language	1	1	0.00137912	0.9704

Figure 11. The logistic regression of overall PA in Mandarin for C1

Nominal Logistic Fit for accuracy

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	3.0449751	4	6.08995	0.1925
RSquare (U)		0.4837		

Effect Likelihood Ratio Tests

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
syllable position	1	1	1.43896214	0.2303
sex of talker	1	1	1.43896214	0.2303
musical ability	1	1	1.89556003	0.1686
spoken language	1	1	1.89556003	0.1686

Figure 12. The logistic regression of the PA of Mandarin syllables for C1.

Nominal Logistic Fit for accuracy
Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	0.41210	3	0.824205	0.8437
RSquare (U)		0.0032		

Effect Likelihood Ratio Tests

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
sex of talker	1	1	0.56223343	0.4534
musical ability	1	1	0.24020126	0.6241
spoken language	1	1	0.06009213	0.8064

Figure 13. The logistic regression of the PA of Mandarin onsets for C1.

Nominal Logistic Fit for accuracy
Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	5.06092	3	10.12185	0.0176*
RSquare (U)		0.0420		

Effect Likelihood Ratio Tests

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
spoken language	1	1	0.15327689	0.6954
musical ability	1	1	0.15327689	0.6954
sex of talker	1	1	9.87887975	0.0017*

Figure 14. The logistic regression of the PA of Mandarin rhymes for C1.

Nominal Logistic Fit for accuracy
Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	4.366176	4	8.732351	0.0681
RSquare (U)		0.0569		

Effect Likelihood Ratio Tests

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
sex of talker	1	1	3.88861707	0.0486*
tone context	1	1	2.10462277	0.1469
musical ability	1	1	2.55443238	0.1100
spoken language	1	1	0.61059129	0.4346

Figure 15. The logistic regression of the PA of Mandarin tones for C1.

Analysis of Error Patterns for Tone Awareness

Error analyses examined error patterns of the English-speaking group learning Mandarin (E1) to provide implications for teaching Mandarin tones to non-native speakers of Chinese. The Chinese group with *Pinyin* literacy (C1) served as the target group. The English-speaking group not learning Mandarin (E2) served as the control group.

The three groups' percent correct identification for each tone in monosyllables is illustrated in Figure 16.

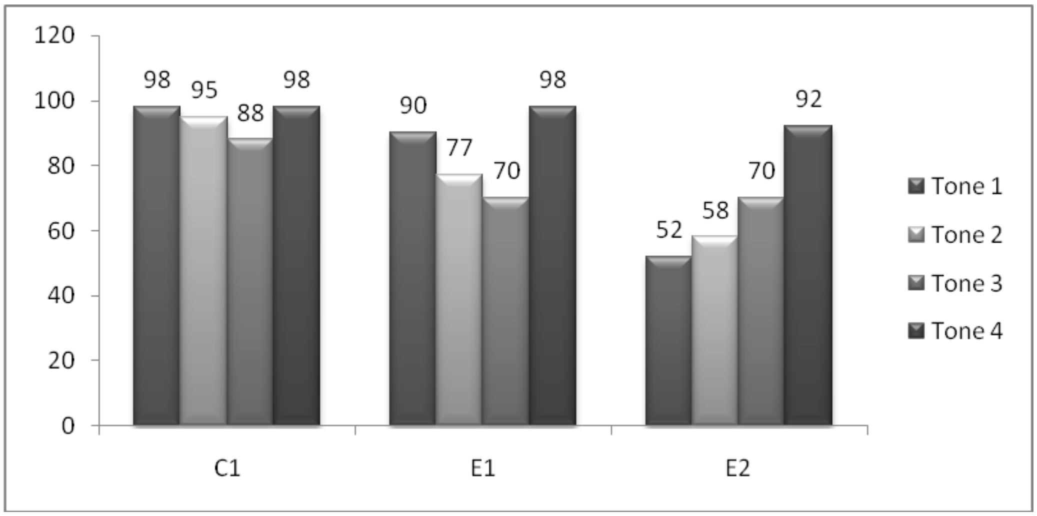


Figure 16. Individual tones in monosyllables identified correctly by group.

Identification accuracy differed from tone to tone and from group to group. The Chinese group with *Pinyin* literacy (C1) showed the smallest range, from 88% to 98% correct. The English-speaking group not learning Mandarin (E2) displayed the widest range, from 52% to 92% correct. Tone 4 was the most accurately identified for all three groups. Tone 3 was the least accurately identified by C1 (88% correct). For E1, tone 3 (70% correct) was the most difficult. For E2, tone 1 was the most difficult (52% correct). Although the magnitude of error was greater for E1, the difficulty order for both groups with *Pinyin* knowledge (C1 and E1) was tone 3 > tone 2 > tone 1 > tone 4. The difficulty order for E2 was different: tone 1 > tone 2 > tone 3 > tone 4.

To control for tone sanhdi, none of the disyllables contained tone 3. The three groups' percent correct identification of tones 1, 2, and 4 in disyllables is illustrated in Figure 17:

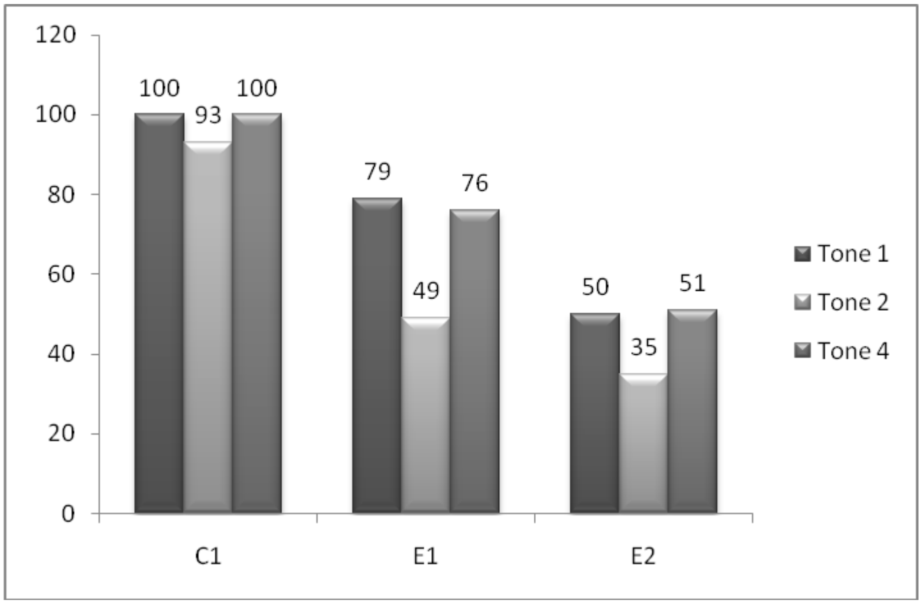
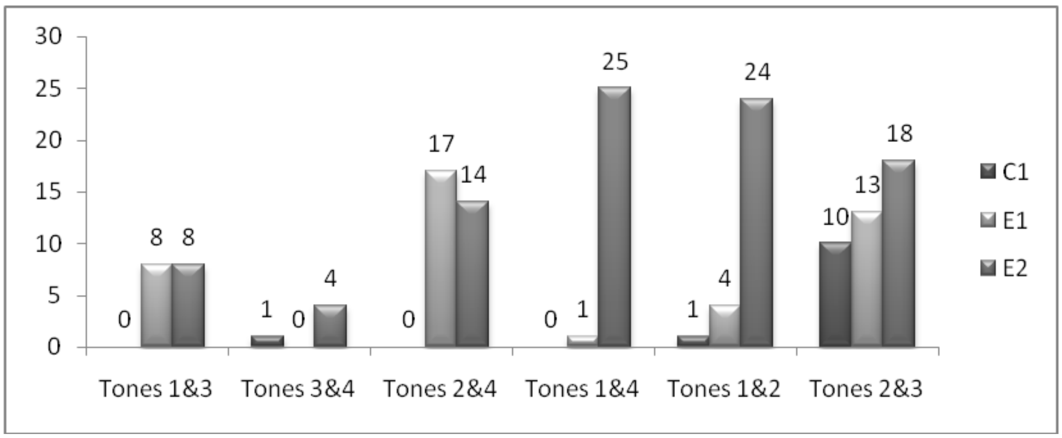


Figure 17. Individual tones in disyllables identified correctly by group

As with tones in monosyllables, C1's identification accuracy had the smallest range. E1showed the widest range of accuracy. For disyllables, tone 2 was the least accurately identified for all groups. For all groups, performance on tones 1 and 4 was similar although the magnitude of difficulty increased by about 25 % both from E2 to E1 and from E1 to C1. In the monosyllabic condition, tone 2 was the second most difficult tone for participants with *Pinyin* knowledge (C1 and E1). Therefore, it is not surprising that tone 2 became the most difficult when tone 3 was excluded in the disyllabic condition.

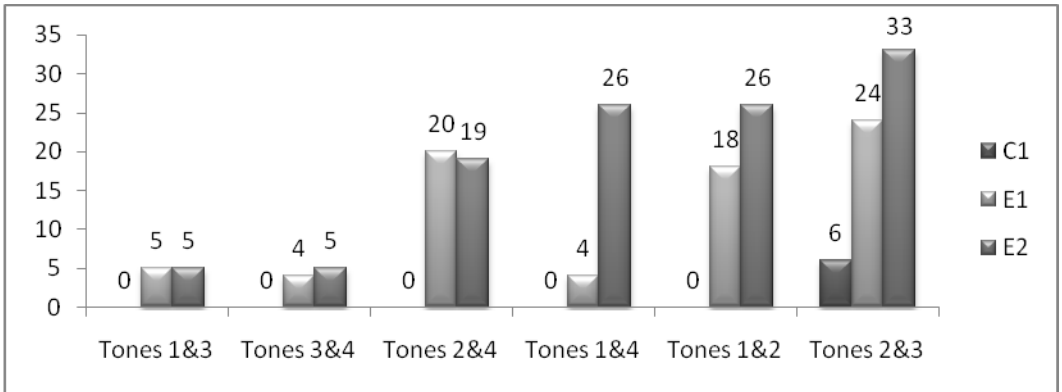
Analysis of tone confusions compares the number of errors made for each tone pair. Figure 18 displays the tone confusions for tones in monosyllables. The results indicate that the patterns of confusions for tones in monosyllables differed across groups. For C1 that had the smallest number of confusions, 10 out of 12 errors were confusion of tones 2/3. For E1 that had substantially fewer confusions than E2, the most confusing pair (40% of the total errors) was tones 2/4 followed by tones 2/3 (30% of the total) and tones 1/3 (17% of the total). All tone pairs posed problems for E2. They made most of the errors on tones 1/4 (27% of the total), followed by tones 1/2 (26%), tones 2/3 (19%), and tones 2/4 (15%).



Group	Tones 1/3	Tones 3/4	Tones 2/4	Tones 1/4	Tones 1/2	Tones 2/3	Total
C1	0	1 (10%)	0	0	1 (10%)	10 (83%)	12
E1	8 (17%)	0	17 (40%)	1 (2%)	4 (9%)	13 (30%)	43
E2	8 (9%)	4 (4%)	14 (15%)	25 (27%)	24 (26%)	18 (19%)	93

Figure 18. Tone pair confusions for tones in monosyllables by group.

Analysis of tone confusions for tones in disyllables is shown in Figure 19:



Group	Tones 1/3	Tones 3/4	Tones 2/4	Tones 1/4	Tones 1/2	Tones 2/3	Total
C1	0	0	0	0	0	6 (100%)	6
E1	5 (7%)	4 (5%)	20 (27%)	4 (5%)	18 (24%)	24 (32%)	75
E2	5 (4%)	5 (4%)	19 (17%)	26 (23%)	26 (23%)	33 (29%)	114

Figure 19. Tone pair confusions for tones in disyllables by group.

The patterns of tone confusions for tones in disyllables were similar among groups. C1 made fewer errors in disyllables than in monosyllables; all errors were misidentification of tone 2 as tone 3. In contrast, the English groups found the identification more difficult in disyllables than in monosyllables. The error made most of the time by E1 was also confusion of tones 2/3(32% of the total errors) although the magnitude was different with 6 errors made by C1 and 24 by E1. Confusions of tones 2/4 (27%) and of tones 1/2 (14%) posed similar problems for E1. E2 also misidentified tone 2 as tone 3 most often (29% of the total errors), followed by tones 1/4 and tones 1/2 (both 23%) as well as tones 2/4 (17%). The participants, who did not know that tone pairs with tone 3 had been excluded, tended to identify tone 2 as tone 3 when they were unsure about tone 2. This also explains why tone 2 was least accurately identified in disyllables.

Table 26 summarizes the effect of independent factor groups on Mandarin PA that were identified as significant in the logistic regression. For overall PA, syllable awareness, and onset awareness, factor groups, which were found to be significant in the final logistic regression with recoded factors, are presented.

Table 26

Values of Independent Factor Groups for the Analysis of PA of Mandarin

Overall PA	Task $p < .0001$	Language group $p < .0001$		
Syllable awareness		Alphabetic literacy $p < .002$	Syllable position $p < .05$	
Onset awareness		Alphabetic literacy $p < .0007$	Item type $p < .0001$	Sex of talker $p < .04$
Rhyme awareness		Language group $p < .005$	Item type $p < .0005$	Sex of talker $p < .0001$
Tone awareness		Language group $p < .0001$	Tone context $p < .0001$	

In summary, for overall performance, logistic regression revealed a significant effect for the factor groups TASK and LANGUAGE GROUP.

For Task 1—syllable awareness, LANGUAGE GROUP and SYLLABLE POSITION had a significant effect in both logistic regression and Chi Square analyses. The effect became even stronger after C1, E1, and E2 were combined into an alphabetic factor and were opposed to C2.

For Task 2—onset awareness, logistic regression showed a significant effect for LANGUAGE GROUP and ITEM TYPE. The effect of LANGUAGE GROUP increased after C1, E1, and E2 were combined into an alphabetic factor and were opposed to C2. Chi Square revealed that items containing onsets present in English favored accurate identification for English speakers. The English-speaking groups learning Mandarin (E1) did not differ significantly from the English-speaking group not learning Mandarin (E2) with respect to item familiarity. Although non-significant in the initial logistic regression, SEX OF TALKER became significant in the final logistic regression.

For Task 3—rhyme awareness, LANGUAGE GROUP, SEX OF TALKER, and ITEM TYPE were significant factor groups in logistic regression. Chi Square also revealed that item type was significant with items containing rhymes present in English disfavoring correct identification. E1 differed significantly from E2 in the identification of items containing rhymes absent in English.

For Task 4—tone awareness, LANGUAGE GROUP and TONE CONTEXT were significant in the logistic regression. Participants scored a better performance in the monosyllabic condition than in the disyllabic condition.

CHAPTER 5 DISCUSSION

This chapter discusses the findings of the present study in terms of the research hypotheses and the analyses presented in previous chapters. Hypotheses 5, 10, 15, 20, and 25, which speak to the effect of L2 LEARNING EXPERIENCE, are not discussed because they were not tested. All other results are discussed in light of previous research. Next, a discussion of error patterns is presented. This is followed by a discussion of implications for future research and for L2 teaching of Mandarin. Finally, a conclusion of the major findings of the present study is presented.

Overall PA

Hypothesis 1, that there is no difference among tasks with respect to the overall PA of Mandarin, is rejected. TASK had a significant effect on the overall PA of Mandarin at $p < .0001$. Participants' performance on syllable awareness (96% correct) was significantly better than on rhyme awareness (73%) which was significantly better than on onset awareness (66%). This result fits well with previous research on English speakers (Høien et al., 1995; Humle et al., 2002) demonstrating that PA is a heterogeneous skill with components which place different demands on speech perception. The difficulty hierarchy is consistent with the developmental sequence documented by Bentin (1992) and Treiman and Zukowski (1996) for children speaking alphabetic languages. Significantly worse than syllable awareness and better than onset awareness, tone awareness was not found to be significantly different from rhyme awareness. Although this is a new finding for PA in Mandarin, it is consistent with Ho and Bryant's (1997) argument that since rhyme and tone are integral to Chinese syllables, these two units tend to be perceived based on overall sound similarity rather than in terms of separate dimensions.

Hypothesis 2, that there is no difference among the four participant groups with respect to the overall PA of Mandarin, is also rejected. LANGUAGE GROUP was a highly significant factor at $p < .0001$. The Chinese group with *Pinyin* literacy (C1) performed better than the other groups, and the English-speaking group learning Mandarin (E1) outperformed their English-speaking counterparts who were not learning Mandarin (E2) and the Chinese group without *Pinyin* literacy (C2). This demonstrates that overall PA is directly influenced by alphabetic literacy in the language being tested. This also explains why although E1's alphabetic literacy in English and *Pinyin* knowledge gained from their Mandarin learning interacted to promote their PA, their performance was still inferior to C1's. The results are in line with studies on PA in Chinese demonstrating that the alphabetic *Pinyin* system promotes adults' PA. For example, Read et al. (1986) found that Chinese speakers with *Pinyin* literacy were significantly better at segmentation skills than those without such knowledge. Leong and Hsia (1996) observed that explicit instructions on *Pinyin* boosted Cantonese-speaking university students' PA as opposed to their counterparts without training. Additionally, Holm and Dodd (1996) found that Hong Kong students who lacked alphabetic knowledge had more difficulty analyzing English segments than Mandarin-speaking students. C2 did not differ significantly from E2, suggesting that the effect of E2's English alphabetic literacy is similar to that of C2's native speaker competence.

Hypothesis 3, that MUSICAL ABILITY is not predictive of the overall PA of Mandarin, is confirmed. This result is inconsistent with the argument of Anvari et al. (2002) that musical training enhances PA. However, the unbalanced distribution of the participants across the three factors tested—six participants in the experienced music group, 13 in the inexperienced music group, and 21 in the non-music group—could have distorted the results. This problem was further compounded by the unbalanced distribution across language groups: No participants in the two Chinese groups belonged to the experienced music group, and all participants in C2 had no musical training.

Hypothesis 4, that SEX OF TALKER is not predictive of the overall PA of Mandarin, is confirmed. The result suggests that whether an item is pronounced by a female or male speaker does not affect overall PA in Mandarin. This finding has no direct parallel to previous research.

Task 1—Syllable Awareness

Hypothesis 6, that there is no difference among the four participant groups with respect to the PA of Mandarin syllables, is rejected. LANGUAGE GROUP was found to significantly affect awareness of Mandarin syllables at $p < .0002$. The Chinese group with *Pinyin* literacy (C1), the English-speaking group learning Mandarin (E1), and the English-speaking group not learning Mandarin (E2) were not significantly different from each other, suggesting that syllable awareness is not cumulatively influenced by alphabetic knowledge. This finding is consistent with studies of adults speaking alphabetic languages (Bertelson et al., 1989; de Gelder, Vroomen, & Bertelson, 1993; Morais et al., 1986) and Chinese (Leong & Hsai, 1996) suggesting that syllable awareness develops in the absence of alphabetic literacy. However, the significant inferiority of the performance of the Chinese group without *Pinyin* literacy (C2) suggests that while sensitivity to syllables develops to some extent spontaneously and independently of alphabetic literacy, it is not entirely a developmental process. This result contrasts with that of Bertelson et al., (1989), de Gelder et al. (1993), and Morais et al. (1986) which demonstrates no significant difference in syllable awareness between the illiterate and literate groups.

Hypothesis 7, that MUSICAL ABILITY is not predictive of the PA of Mandarin syllables, is confirmed. Participants' musical training did not significantly affect awareness of Mandarin syllables. This could be due to close-to-ceiling performance of all groups as well as the unbalanced distribution of the participants across musical factors and language groups.

Hypothesis 8, that sex of talker is not predictive of the PA of Mandarin syllables, is also confirmed. This finding has no direct parallel to previous research.

Hypothesis 9, that SYLLABLE POSITION is not predictive of the PA of Mandarin syllables, is rejected. SYLLABLE POSITION significantly affected syllable awareness at $p < .05$. Participants judged whether a pair of disyllables shared the first syllable less accurately than whether they shared the final syllable. This finding has no direct parallel to previous work on PA in Mandarin. This may be an effect of the experimental design. All items were disyllables. When asked to determine whether a pair had the same final syllables, participants readily reached a conclusion that the final syllables must be the same if they had deemed the first syllables to be different. Therefore, while syllables in initial position had to be identified without a hypothesis, syllables in second position could be identified by testing a hypothesis formed when participants heard the syllables in initial position.

Task 2—Onset Awareness

Hypothesis 11, that there is no difference among the four participant groups with respect to the PA of Mandarin onsets, is rejected. LANGUAGE GROUP was a significant factor at $p < .0001$. The Chinese group without *Pinyin* literacy (C2) performed significantly worse than the three literate groups. This result is compatible with previous research on adults speaking alphabetic languages (Bertelson et al., 1989; Bryne & Ledez, 1983; Liberman et al., 1985; Morais et al., 1979, 1986, 1987; Read & Ruyter, 1985) and Chinese (Holm & Dodd, 1996; Leong & Hsia, 1996; Read et al., 1986) suggesting that onset/phoneme awareness develops in relation to alphabetic experience. However, as in the analysis of syllable awareness, the biliteracy of the Chinese group with *Pinyin* literacy (C1) did not give them an advantage over the two English-speaking groups. This may suggest that although alphabetic literacy enhances perception of subsyllabic units in Mandarin, the effect of orthographic literacy is not cumulative. Since the stimuli were non-words, it may also suggest that alphabetic literacy overrides native language advantage.

Hypothesis 12, that MUSICAL ABILITY is not predictive of the PA of Mandarin onsets, is confirmed. This finding is not compatible with Moritz (2007) suggesting that intensive musical instruction promoted participants' onset awareness. However, as for overall PA and syllable awareness, the results could have been skewed by the unbalanced distribution of the participants.

Hypothesis 13, that SEX OF TALKER is not predictive of the PA of Mandarin onsets, is confirmed. The result contrasts with K. Johnson (1991) suggesting that sex of talker significantly affected whether English speakers identified [ʃ]-[s] continua as [ʃ] or [s].

Hypothesis 14, that ITEM TYPE is not predictive of English speakers' PA of Mandarin onsets, is rejected. The two English-speaking groups performed significantly better on Mandarin items containing onsets present in English than those containing onsets absent in English, consistent with cross-language studies of adult non-native consonant perception (Miyawaki et al., 1975; Polka, 1991; Takata & Nábělek, 1990). This demonstrates a difficulty hierarchy based on absence or presence of L2 segments in participants' L1 proposed by Stockwell and Bowen (1983). That the English-speaking group learning Mandarin (E1) was not significantly different from the English-speaking group not learning Mandarin (E2) for onsets either present or absent in English suggests that E1's exposure to Mandarin was not sufficient to trigger a familiarity effect. It is not known whether the use of Mandarin non-words may have contributed to their error rate since this group had studied all sounds in the test items during their Mandarin learning.

Task 3—Rhyme Awareness

Hypothesis 16, that there is no difference among the four participant groups with respect to the PA of Mandarin rhymes, is rejected. The Chinese group without *Pinyin* literacy (C2) was significantly worse than the other three groups with either *Pinyin* or English alphabetic literacy. Like the result for onset awareness, this result demonstrates that alphabetic literacy contributes more strongly to the PA of Mandarin subsyllabic units than does native speaker advantage. The finding that rhyme awareness does not develop independently of alphabetic literacy is inconsistent with studies of adults speaking alphabetic languages (Morais et al., 1986) and Chinese (Leong & Hsai, 1996). However, this finding converges with that of Holm and Dodd (1996) who found that Hong Kong students without alphabetic literacy performed significantly worse than the other groups with alphabetic literacy on rhyme awareness. The English-speaking group learning Mandarin (E1) significantly outperformed the biliterate C1 group that was not significantly different from E2 that was unfamiliar with Mandarin. It is reasonable that E1 outperformed E2 considering E1's *Pinyin* knowledge. C1's inferiority to E1is unexpected, though.

Hypothesis 17, that MUSICAL ABILITY is not predictive of the PA of Mandarin rhymes, is confirmed. This finding is not compatible with Moritz (2007) who demonstrated that intensive musical instruction promoted participants' awareness of English rhymes. Again, the result might be explained by the unbalanced distribution of the participants.

Hypothesis 18, that SEX OF TALKER is not predictive of the PA of Mandarin rhymes, is rejected. Contrary to the result for onset awareness, SEX OF TALKER was significant at $p < .0001$. The items pronounced by the female speaker were identified correctly less often than those pronounced by the male speaker. This finding has no direct parallel to previous work.

Hypothesis 19, that ITEM TYPE is not predictive of English speakers' PA of Mandarin rhymes, is rejected. This factor group significantly affected participants' performance at $p < .0005$. However, Mandarin items containing rhymes present in English were identified significantly less accurately than those containing rhymes absent in English. This result is unexpected given the perceptual difficulty order proposed by

Stockwell and Bowen (1983) and is inconsistent with previous research on perception of non-native vowels (e.g., Bohn & Flege, 1990; Polka, 1995) suggesting perceptual difficulty caused by L2 vowels absent in L1. A close examination of the test items used for the rhyme awareness task revealed that the design of the test items could have contributed to this result. Half of the 20 test sets had Mandarin non-words whose rhymes had equivalents in English (Group A), and half had Mandarin non-words whose rhymes were absent in English (Group B). It was found that six out of ten sets in Group A included two items *qōu* and *qō*, which may sound alike to non-native speakers of Chinese. In contrast, none of the ten sets in Group B included potentially confusing items. It was also observed that the English group learning Mandarin (E1) performed significantly differently from the English group not learning Mandarin (E2) on the identification of items containing rhymes absent in English, suggesting that E1's familiarity with those items due to their Mandarin learning may have enhanced their performance. This finding is consistent with that of Bohn and Flege (1990) that experienced and inexperienced German-speaking learners of English only differed significantly in their perception of an English vowel contrast absent in German.

Task 4—Tone Awareness

Hypothesis 21, that there is no difference among the four participant groups with respect to the PA of Mandarin tones, is rejected. LANGUAGE GROUP significantly affected tone awareness at $p < .0001$. The Chinese group with *Pinyin* literacy (C1) was superior at tone identification (96% correct) to both the E1 group with *Pinyin* knowledge (75%) and the E2 group without such knowledge (53%). This result is consistent with previous research (Bent et al., 2006; Lee et al., 1996) suggesting that native speakers of

Mandarin performed significantly better than native speakers of English due to the language-specific tonal knowledge of native speakers of Mandarin. For example, Bent et al. (2006) found a significant difference in tone identification between native speakers of Mandarin (99% correct) and native speakers of English without experience of Mandarin (58%). The E1 group learning Mandarin was superior to the E2 group not learning Mandarin, consistent with Leather (1990), Lu (1993), and Wang et al. (1998, 1999) who indicate that training can enhance tone awareness of speakers of non-tonal languages. Unexpectedly, the Chinese group without *Pinyin* literacy (C2) performed as well as E1. This finding suggests that although tone awareness develops in relation to native language, literacy instruction that makes tonal contrasts explicit may enhance tone perception.

Hypothesis 22, that MUSICAL ABILITY is not predictive of the PA of Mandarin tones, is confirmed. The result contrasts with Gottfried and Riester (2000) using a tone identification task, Gottfried et al. (2004) using a tone discrimination task, and Alexander et al. (2005) using both tasks. These studies found that participants with musical training were superior at tone identification to those without it. As in the other tasks of the present study, the discrepancy may have resulted from the unbalanced distribution of the participants.

Hypothesis 23, that SEX OF TALKER is not predictive of the PA of Mandarin tones, is confirmed. SEX OF TALKER was not found to significantly affect participants' tone awareness. However, Leather (1983) and Moore and Jongman (1997) suggest that talker variability based on fundamental frequency (*F*0) conditioned tone awareness.

Hypothesis 24, that TONE CONTEXT is not predictive of the PA of Mandarin tones, is rejected. Participants performed significantly better ($p < .0001$) on tones in monosyllables than on tones in disyllables. Analyses of individual groups found that tone context did not affect the two Chinese groups due to their native proficiency in Mandarin, but did significantly impact the two English-speaking groups. The inferior performance of the E2 group not learning Mandarin is in line with Broselow et al. (1987) and Winitz (1981) who also examined English speakers with no prior exposure to Mandarin. Lu (1993) suggests that tone context only affects Mandarin tone awareness for speakers of non-tonal languages with little experience of Mandarin. In his study, tone context had a significant effect on English speakers when they began learning Mandarin, but not at the end of their first semester. His conclusion is not born out in the present study. E1, who were tested at the end of their second semester, had studied Mandarin even longer than participants in Lu's study. However, E1 listened to a stimulus in the disyllabic condition only once while participants in Lu's study heard each stimulus three times. This difference may account for not only this discrepancy but also greater accuracy (above 90% on all tones in disyllables) attained by Lu's participants tested at the end of first semester.

SPOKEN LANGUAGE for the Chinese Group with *Pinyin* Literacy (C1)

Hypothesis 26, that typological distance from Mandarin is not predictive of the overall PA of Mandarin for Chinese speakers with *Pinyin* literacy (C1), is confirmed. Hypotheses 27-30, that typological distance from Mandarin is not predictive of the PA of Mandarin syllables, onsets, rhymes, and tones for Chinese speakers with *Pinyin* literacy (C1), are also confirmed. Half of them (Group A) speak as the first language a dialect of

Northern Speech, to which Mandarin also belongs. The other half (Group B) speak one of the other seven Chinese languages as the first language. Group A's spoken languages are thus typologically closer to Mandarin than those of Group B. Research on speakers of both alphabetic languages (Bruck et al., 1997; Caravolas & Bruck, 1993; Cossu et al., 1988) and Chinese (Cheung, 2003; Cheung et al., 2001) demonstrates that PA of preliterate children is influenced by phonological units of their spoken languages. It was anticipated that the effect of spoken language might appear for adults as well. However, the degree of typological distance between Group A and Group B did not significantly affect either their overall PA or PA of four components. The typological distance between the two groups may have been insufficient. Alternatively, fluency in Mandarin and *Pinyin* literacy may have reduced the effect of their spoken language.

Error Analyses

Comparison of error patterns of English-speakers learning Mandarin (E1) with Chinese speakers with *Pinyin* literacy (C1) and English speakers not learning Mandarin (E2) revealed a facilitatory effect of instruction on non-native acquisition of Mandarin tones. Although E1 had only studied Mandarin for two semesters, their performance was close to the native norm and significantly different from that of their English-speaking counterparts with no experience of Mandarin.

With respect to identification accuracy in the monosyllabic condition, E1's identification was 38% more accurate for tone 1 and 19% for tone 2 than E2. Although the increase of tone 4 was small (from E2's 92% to E1's 98%), E1's perceptual instruction resulted in the native-like performance of C1's 98%. The identification of tone 3 was the same for E1 and E2. There has been no research comparing English speakers learning Mandarin and those not learning Mandarin on tone perception. However, Lu (1993) and Wang et al. (1998, 1999) investigated the improvement of American college students in tone identification after perceptual training. In Lu (1993), performance improved by 5% for tone 1, 18% for tone 2, and 12% for tone 4, but decreased by 4% for tone 3 from the test taken at the beginning of Mandarin learning to the test taken at the end of one-semester learning. Lu attributed the better performance on tone 3 in the first test to participants' tendency to identify both tone 2 and tone 3 as tone 3. In Wang et al. (1998), the trained group improved their identification on all tones from the pretest to the posttest (11% for tone 1, 7% for tone 2, 20% for tone 3, and 6% for tone 4). In Wang et al. (1999), perceptual training improved tone 3 most and tone 4 least. Although failing to yield converging results, these studies suggest that tone awareness of language-learning adults can be improved through focused exposure to tonal contrasts.

In addition, this study found that the performance range was the smallest for C1 (88% to 98% correct) and largest for E2 (52% to 92%). A similar result was reported by Bent et al. (2006) with a range of 96% to 100% for Mandarin speakers and that of 26% to 88% for English speakers without experience of Mandarin. The present study also found that the difficulty order for E1 was tone 3 > tone 2 > tone 1 > tone 4. Kiriloff (1969), who examined university-level beginning learners of Mandarin in Australia, reported the same pattern. The difficulty order for the E2 group not learning Mandarin was tone 1 > tone 2 > tone 3 > tone 4, which was close to that found for English speakers without prior exposure to Mandarin in Broselow et al. (1987): tone 2 > tone 1 > tone 3 > tone 4. Along with other studies, the present study demonstrates that the more tonal knowledge speakers of non-tonal languages have, the closer their tone awareness is to the native norm.

With respect to identification accuracy in the disyllabic condition, the error patterns of the three groups were similar despite significant differences in accuracy. As in the monosyllabic condition, perceptual instruction improved performance from E2 to E1with 29% for tone 1, 14% for tone 2, and 25% for tone 4. This finding is consistent with Lu (1993) who found a 25% improvement for tone 1, 34% for tone 2, and 9% for tone 4 from the beginning to the end of the semester. For all groups, tone 2 was the most difficult tone with close performances for tones 1 and 4. A different difficulty pattern was reported by Broselow et al. (1987) and Lu (1993) for tones of the first syllable in disyllables: tone 4 > tone 2 > tone 1. However, the above two studies included all tone pairs, so exclusion of pairs with tone 3 from this study may explain the different results.

Regarding tone confusions in the monosyllabic condition, the results indicate that perceptual instruction substantially reduced E1's errors (n = 43) as opposed to E2 (n = 93). Specifically, it eliminated E1's confusion of tones 3/4 and caused E1 even to surpass C1. The greatest improvement was shown for confusion of tones 1/4 (E1's 1 error vs. E2's 25) and for that of tones 1/2 (4 vs. 24). Confusions of tones 1/3 and tones 2/4 did not improve, pointing to possible U-shaped behavior. These results are similar to that of Wang et al. (1999) who found that the trained group was less confused by all tone pairs. The same result appeared for Lu's (1993) participants when tested at the end of first-semester Mandarin learning.

The present study also observed that C1 demonstrated ceiling performance with only 12 errors, 10 of which were confusion of tones 2/3. This finding is compatible with

L1 acquisition research suggesting that tones 2/3 are the most confusable (e.g., Clumeck, 1980; Li & Thompson, 1977). The most confusing tone pair for E1 was tones 2/4 (40% of total errors), followed by tones 2/3 (30%) and tones 1/3 (17%) with very few or no errors on other tone contrasts. All of the tone contrasts except tones 3/4 were confusing to E2 with most of the errors made on tones 1/4 (27% of total errors), followed by tones 1/2 (26%) and tones 2/3 (19%). Interestingly, this finding is inconsistent with other studies of speakers of non-tonal languages learning Mandarin (Kiriloff, 1969; Leather, 1990; Lu, 1993; Wang et al., 1998, 1999) that consistently suggest that tones 2/3 are the most confusing pair for speakers of non-tonal languages.

Regarding tone confusions in the disyllabic condition, improvement was again greatest for confusion of tones 1/4 (E1's 4 errors vs. E2's 26). This finding is consistent with that of Lu (1993) that the confusion decreased most for tones 1/4 from the beginning of Mandarin learning to the end of one-semester learning. As in the monosyllabic condition, major improvement was also shown for confusion of tones 1/2 (E1'18 vs. E2'26) and of tones 2/3 (E1'24 vs. E2'33), but not for the other pairs. The most confusing tone pair was misidentification of tone 2 as tone 3 for all three groups (6 errors for C1, 24 for E1, and 33 for E2). E1 made a lot of errors on other two pairs, tones 2/4 (20 errors) and tones 1/2 (18 errors). Comparison of the data in this condition with that in the monosyllabic condition revealed that the tendency to confuse tones 1 and 2 increased substantially. E2 also made considerable errors on tones 2/4 and tones 1/2. The results indicate that tone training had a stronger facilitatory effect for E1 in the monosyllabic condition than in the disyllabic condition. In Lu's study, however, participants listened to each stimuli three times and made considerably fewer errors on all tone pairs in the disyllabic condition when tested at the end of first-semester Mandarin learning than E1 participants in the present study. In his study, tones 2/4 were the most confusing pair, but there were only 18 errors for this pair.

Limitations and Implications for Future Research

One limitation of the present study is that this study was limited by available subject pools. The effect of the factor group L2 LEARNING EXPERIENCE could not be tested because most of the participants were at least bilingual. To examine the effect of this variable, future research should include groups with balanced numbers of participants with and without L2 experience. Similarly, the distribution of the participants across musical factors and language groups was problematic. Future research should consider a balanced distribution of participants with no musical training and some musical experience as well as participants who are musical experts in each language group.

Another limitation is related to item design which should be improved for several tasks. In the syllable awareness task, participants tended to determine whether a pair of disyllables shared the final syllable more accurately than whether they shared the first syllable. To better test the effect of SYLLABLE POSITION, future research should ask participants to determine whether a pair of trisyllables share the first or final syllable. It was also observed that English speakers performed significantly better on Mandarin rhymes absent in English than on those equivalent to English rhymes. To determine whether this was the result of the use of confusing segments in test items, future research should include test items that are not confusable. To determine whether the use of non-words resulted in the absence of an advantage of the Chinese group with *Pinyin* literacy

(C1) over English speakers on syllable, onset, and rhyme awareness tasks, future research should also use Mandarin words to test the effect of L1 *Pinyin* literacy.

This study examined only the identification of the tone of the first syllable in disyllables. To further test the effect of TONE CONTEXT, future research needs to investigate the performance on the tone of the second syllable in disyllables. The modification suggested for the syllable awareness task is applicable here as well; trisyllables should be used as well. Both disyllables and trisyllables could be tested in a carrier sentence. To test whether the effect of tone context decreases with tonal knowledge of speakers of non-tonal languages, more research is needed to compare such speakers at different levels of Mandarin learning.

The final limitation of the present study is related to two variables which were not found to be significant. SPOKEN LANGUAGE did not have an impact on adult native speakers of Chinese with *Pinyin* literacy (C1). To determine whether this variable only affects pre-readers as indicated in the published literature, future research should compare literate and preliterate participants. Moreover, the results for SEX OF TALKER are puzzling, so more research is needed to test whether this variable affects the various types of PA.

Implications for Teaching Mandarin to Non-native Speakers of Chinese

The present study provides a number of implications for teaching Mandarin. The results confirm that Mandarin sounds common to both Mandarin and English were easier for native English speakers to learn than sounds absent in English. Therefore, it is suggested that Mandarin teachers clarify the correspondence or difference between

Mandarin and English sounds with emphasis placed on L2 learners' perception of unfamiliar sounds.

This study additionally demonstrates that while English speakers' L1 alphabetic literacy promoted their PA of Mandarin syllables, onsets, and rhymes, their performance on tone awareness was only enhanced by perceptual instruction on tonal contrasts. Instruction did not improve E1's performance on tone 3 and did not reduce E1's confusions of tones 1/3 and tones 2/4. In the monosyllabic condition, tone 3 and tone 2 were more difficult than tone 1 and tone 4 for English speakers learning Mandarin. With respect to tone pairs, tones 2/4 and tones 2/3 were confusing to E1. Therefore, it is suggested that Mandarin teachers provide their students with exercises emphasizing the distinction between tone 3 and other tones and the distinction between these confusing pairs.

This study also confirms that tone context influences English speakers' tone awareness. Although E1 had learned Mandarin for two semesters, they performed significantly worse on individual tones and were confused by more tone pairs in the disyllabic condition than in the monosyllabic condition. Since most of the tone pairs (especially tones 2 and 3) posed difficulty for English speakers learning Mandarin despite the exclusion of pairs with tone 3, tones should be taught in context, consistent with the proposal made by Lu (1993). As Lu argues, learning tones in two-syllable words can promote tone awareness in longer sequences because tones in a disyllable are either preceded or followed by another tone. Therefore, it is suggested that two-syllable words with all tone pairs including those with tone sandhi should be used in tone exercises.

Conclusion

The present study investigates the relationship between eight independent variables and PA in Mandarin. While the results for the factor groups MUSICA ABILITY and SEX OF TALKER are puzzling and, as discussed above, deserving of additional research, the study makes a number of substantive contributions. In addition to confirming the heterogeneity of overall PA established in earlier research, the results demonstrate the relative contributions of several independent variables and raises questions about the relevance of several others. It also provides implications for instructional practice.

The results presented in Table 26 demonstrate that prior linguistic experience is highly correlated with overall PA ($p < .0001$). However, linguistic experience contributes differentially to tone awareness ($p < .0001$) and rhyme awareness ($p < .005$). The differential effect of native language experience and alphabetic knowledge on syllable awareness is especially intriguing as it suggests that syllable awareness is not entirely a developmental phenomenon. The results additionally indicate that language experience in the form of alphabetic literacy differentially overrides native language experience for onset awareness ($p < .0007$) and syllable awareness ($p < .002$). These data also suggest that the effect of literacy on PA in Mandarin is not cumulative since the Chinese group with L1 *Pinyin* literacy and L2 English literacy (C1) differed neither from the English-speaking group with L1 English literacy and limited L2 *Pinyin* literacy (E1) and the monoliterate English-speaking group (E2) on the onset awareness task nor from E2 on the rhyme awareness task. The relative effect of native language experience/ literacy with respect to the contextual variables of syllable position (literacy > syllable position), item type for onsets (item type > literacy), item type for rhymes (item type > language experience), and tone context (tone context = language experience) is also of considerable interest.

The results of the study also confirm that language-specific tonal knowledge can be enhanced by instruction. By establishing a native speaker target and establishing a baseline for English speakers learning Mandarin, the results point specifically to the relative difficulty of the four tones both in mono- and disyllables. It also reveals relative patterns of confusion across three language groups: Chinese speakers, Mandarin learners, and native speakers of English.

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APPENDICES

Appendix A: Chinese version of questionnaire and answer sheet

一．调查表：请回答以下问题。

1．年龄_________

2．你的方言__________________________

3．母亲的方言______________，父亲的方言_____________，

与家庭成员所用的方言____

4. 其他你会的方言____

5. 你什么时候开始学英语？_____________________________

6. 你在美国或其他的讲英语的国家所呆的时间____________________________

7. 其他你学过的外语（请说明是什么语言，你什么时候开始学的，如果你停止学了，是什么时候）：

1）_______________________ ____________________ _____________________

2) ________________________ ___________________ ______________________

3) ________________________ ___________________ ______________________

4) ________________________ ___________________ ______________________

5) ________________________ ___________________ ______________________

8. 音乐水平：1）从来没有受过音乐训练______，2）业余水平______，

3）专业水平_____

9．如果你能读下面这两个句子，请选折“可以”。如果不能，请选折“不”。

Wǒ shì dà xué shēng.　可以______　不_____

我是大学生。　　　可以______　不_____

二．答题卡：请认真听每一组词，然后选折你的答案。

项目一：音节辨识（音节是不是相同）

1．是_________不是__________　2. 是_________不是__________
3. 是_________不是__________　4. 是_________不是__________
5. 是_________不是__________　6. 是_________不是__________
7. 是_________不是__________　8. 是_________不是__________
9. 是_________不是__________　10. 是_________不是__________
11. 是_________不是__________　12. 是_________不是__________
13. 是_________不是__________　14. 是_________不是__________
15. 是_________不是__________　16. 是_________不是__________
17. 是_________不是__________　18. 是_________不是__________
19. 是_________不是__________　20. 是_________不是__________

项目二：声母辨识

1. 1)_____, 2)_____, 3)______　**2**. 1)_____, 2)_____, 3)______

3. 1)_____, 2)_____, 3)______　**4**. 1)_____, 2)_____, 3)______

5. 1)_____, 2)_____, 3)______　**6**. 1)_____, 2)_____, 3)______

7. 1)_____, 2)_____, 3)______　**8**. 1)_____, 2)_____, 3)______

9. 1)_____, 2)_____, 3)______　**10**. 1)_____, 2)_____, 3)______

11. 1)_____, 2)_____, 3)______　**12**. 1)_____, 2)_____, 3)______

13. 1)_____, 2)_____, 3)______　**14**. 1)_____, 2)_____, 3)______

15. 1)_____, 2)_____, 3)______　**16**. 1)_____, 2)_____, 3)______

17. 1)_____, 2)_____, 3)______　**18**. 1)_____, 2)_____, 3)______

19. 1)_____, 2)_____, 3)______　**20**. 1)_____, 2)_____, 3)______

项目三：韵母辨识

1. 1)______, 2)______, 3)_______ **2**. 1)______, 2)______, 3)_______

3. 1)______, 2)______, 3)_______ **4**. 1)______, 2)______, 3)_______

5. 1)______, 2)______, 3)_______ **6**. 1)______, 2)______, 3)_______

7. 1)______, 2)______, 3)_______ **8**. 1)______, 2)______, 3)_______

9. 1)______, 2)______, 3)_______ **10**. 1)______, 2)______, 3)_______

11. 1)______, 2)______, 3)_______ **12**. 1)______, 2)______, 3)_______

13. 1)______, 2)______, 3)_______ **14**. 1)______, 2)______, 3)_______

15. 1)______, 2)______, 3)_______ **16**. 1)______, 2)______, 3)_______

17. 1)______, 2)______, 3)_______ **18**. 1)______, 2)______, 3)_______

19. 1)______, 2)______, 3)_______ **20**. 1)______, 2)______, 3)_______

项目四：声调辨识

I. 单音节

1. 1)___, 2)_____, 3)______, 4)_____ **2**. 1)___, 2)_____, 3)______, 4)_____

3. 1)___, 2)_____, 3)______, 4)_____ **4**. 1)___, 2)_____, 3)______, 4)_____

5. 1)___, 2)_____, 3)______, 4)_____ **6**. 1)___, 2)_____, 3)______, 4)_____

7. 1)___, 2)_____, 3)______, 4)_____ **8**. 1)___, 2)_____, 3)______, 4)_____

9. 1)___, 2)_____, 3)______, 4)_____ **10**. 1)___, 2)_____, 3)______, 4)_____

11. 1)___, 2)_____, 3)______, 4)_____ **12**. 1)___, 2)_____, 3)______, 4)_____

13. 1)___, 2)_____, 3)______, 4)_____ **14**. 1)___, 2)_____, 3)______, 4)_____

15. 1)___, 2)_____, 3)______, 4)_____ **16**. 1)___, 2)_____, 3)______, 4)_____

17. 1)___, 2)_____, 3)______, 4)_____ **18**. 1)___, 2)_____, 3)______, 4)_____

19. 1)___, 2)_____, 3)______, 4)_____ **20**. 1)___, 2)_____, 3)______, 4)_____

21. 1)___, 2)_____, 3)______, 4)_____ **22**. 1)___, 2)_____, 3)______, 4)_____

23. 1)___, 2)_____, 3)______, 4)_____ **24**. 1)___, 2)_____, 3)______, 4)_____

II. 双音节

1. 1)___, 2)_____, 3)______, 4)_____ **2**. 1)___, 2)_____, 3)______, 4)_____

3. 1)___, 2)_____, 3)______, 4)_____ **4**. 1)___, 2)_____, 3)______, 4)_____

5. 1)___, 2)_____, 3)______, 4)_____ **6**. 1)___, 2)_____, 3)______, 4)_____

7. 1)___, 2)_____, 3)______, 4)_____ **8**. 1)___, 2)_____, 3)______, 4)_____

9. 1)___, 2)_____, 3)______, 4)_____ **10**. 1)___, 2)_____, 3)______, 4)_____

11. 1)___, 2)_____, 3)______, 4)_____ **12**. 1)___, 2)_____, 3)______, 4)_____

13. 1)___, 2)_____, 3)______, 4)_____ **14**. 1)___, 2)_____, 3)______, 4)_____

15. 1)___, 2)_____, 3)______, 4)_____ **16**. 1)___, 2)_____, 3)______, 4)_____

17. 1)___, 2)_____, 3)______, 4)_____ **18**. 1)___, 2)_____, 3)______, 4)_____

19. 1)___, 2)_____, 3)______, 4)_____ **20**. 1)___, 2)_____, 3)______, 4)_____

21. 1)___, 2)_____, 3)______, 4)_____ **22**. 1)___, 2)_____, 3)______, 4)_____

23. 1)___, 2)_____, 3)______, 4)_____ **24**. 1)___, 2)_____, 3)______, 4)_____

Appendix B: English version of questionnaire and answer sheet

I. Questionnaire: Before the experiment, please answer the following questions:

1. Your age________
2. Your first language_________
3. Mother's first language________; father's first language________;

   languages spoken at home____________, ____________, _______________,

   ___________, _________________, _________________.
4. Other languages you can speak fluently__________, _____________,

   ________________, _______________, __________________.
5. Other foreign languages you have learned (please tell what each language is, when you started to learn, and when you stopped learning/using if you did):

	Language	Started to learn	Stopped learning/using
1)	________________	______________________	_____________________
2)	________________	______________________	_____________________
3)	________________	______________________	_____________________
4)	________________	______________________	_____________________
5)	________________	______________________	_____________________
6)	________________	______________________	_____________________

6. Musical competence (please choose the following option that can best describe your musical competence):

1) No musical training_______; 2) Amateur level_______; 3) Expert level)_______

7. Can you read the following sentences? If you can read them, please mark *yes*; if not, mark *no*.

Wǒ shì dà xué shēng. Yes ______ No_____

我是大学生。Yes_______ No________

II. Answer Sheet—please listen to each item carefully and mark your choice:

Task 1: Syllable same-different

1. Yes_____ No______ 2. Yes_____ No______

3. Yes_____ No______ 4. Yes_____ No______

5. Yes_____ No______ 6. Yes_____ No______

7. Yes_____ No______ 8. Yes_____ No______

9. Yes_____ No______ 10. Yes_____ No______

11. Yes_____ No______ 12. Yes_____ No______

13. Yes_____ No______ 14. Yes_____ No______

15. Yes_____ No______ 16. Yes_____ No______

17. Yes_____ No______ 18. Yes_____ No______

19. Yes_____ No______ 20. Yes_____ No______

Task 2: Onset oddity

1. 1)_____, 2)_____, 3)______ **2**. 1)_____, 2)_____, 3)______

3. 1)_____, 2)_____, 3)______ **4**. 1)_____, 2)_____, 3)______

5. 1)_____, 2)_____, 3)______ **6**. 1)_____, 2)_____, 3)______

7. 1)_____, 2)_____, 3)______ **8**. 1)_____, 2)_____, 3)______

9. 1)_____, 2)_____, 3)______ **10**. 1)_____, 2)_____, 3)______

11. 1)______, 2)______, 3)_______ **12**. 1)______, 2)______, 3)_______

13. 1)______, 2)______, 3)_______ **14**. 1)______, 2)______, 3)_______

15. 1)______, 2)______, 3)_______ **16**. 1)______, 2)______, 3)_______

17. 1)______, 2)______, 3)_______ **18**. 1)______, 2)______, 3)_______

19. 1)______, 2)______, 3)_______ **20**. 1)______, 2)______, 3)_______

Task 3: Rhyme oddity

1. 1)______, 2)______, 3)_______ **2**. 1)______, 2)______, 3)_______

3. 1)______, 2)______, 3)_______ **4**. 1)______, 2)______, 3)_______

5. 1)______, 2)______, 3)_______ **6**. 1)______, 2)______, 3)_______

7. 1)______, 2)______, 3)_______ **8**. 1)______, 2)______, 3)_______

9. 1)______, 2)______, 3)_______ **10**. 1)______, 2)______, 3)_______

11. 1)______, 2)______, 3)_______ **12**. 1)______, 2)______, 3)_______

13. 1)______, 2)______, 3)_______ **14**. 1)______, 2)______, 3)_______

15. 1)______, 2)______, 3)_______ **16**. 1)______, 2)______, 3)_______

17. 1)______, 2)______, 3)_______ **18**. 1)______, 2)______, 3)_______

19. 1)______, 2)______, 3)_______ **20**. 1)______, 2)______, 3)_______

Task 4: Tone identification

Monosyllables

1. 1)____, 2)_____, 3)______, 4)_____ **2**. 1)____, 2)_____, 3)______, 4)_____

3. 1)____, 2)_____, 3)______, 4)_____ **4**. 1)____, 2)_____, 3)______, 4)_____

5. 1)____, 2)_____, 3)______, 4)_____ **6**. 1)____, 2)_____, 3)______, 4)_____

7. 1)____, 2)_____, 3)______, 4)_____ **8**. 1)____, 2)_____, 3)______, 4)_____

9. 1)____, 2)_____, 3)______, 4)_____ **10**. 1)____, 2)_____, 3)______, 4)_____

11. 1)___, 2)_____, 3)______, 4)_____ **12**. 1)___, 2)_____, 3)______, 4)_____

13. 1)___, 2)_____, 3)______, 4)_____ **14**. 1)___, 2)_____, 3)______, 4)_____

15. 1)___, 2)_____, 3)______, 4)_____ **16**. 1)___, 2)_____, 3)______, 4)_____

17. 1)___, 2)_____, 3)______, 4)_____ **18**. 1)___, 2)_____, 3)______, 4)_____

19. 1)___, 2)_____, 3)______, 4)_____ **20**. 1)___, 2)_____, 3)______, 4)_____

21. 1)___, 2)_____, 3)______, 4)_____ **22**. 1)___, 2)_____, 3)______, 4)_____

23. 1)___, 2)_____, 3)______, 4)_____ **24**. 1)___, 2)_____, 3)______, 4)_____

Disyllables

1. 1)___, 2)_____, 3)______, 4)_____ **2**. 1)___, 2)_____, 3)______, 4)_____

3. 1)___, 2)_____, 3)______, 4)_____ **4**. 1)___, 2)_____, 3)______, 4)_____

5. 1)___, 2)_____, 3)______, 4)_____ **6**. 1)___, 2)_____, 3)______, 4)_____

7. 1)___, 2)_____, 3)______, 4)_____ **8**. 1)___, 2)_____, 3)______, 4)_____

9. 1)___, 2)_____, 3)______, 4)_____ **10**. 1)___, 2)_____, 3)______, 4)_____

11. 1)___, 2)_____, 3)______, 4)_____ **12**. 1)___, 2)_____, 3)______, 4)_____

13. 1)___, 2)_____, 3)______, 4)_____ **14**. 1)___, 2)_____, 3)______, 4)_____

15. 1)___, 2)_____, 3)______, 4)_____ **16**. 1)___, 2)_____, 3)______, 4)_____

17. 1)___, 2)_____, 3)______, 4)_____ **18**. 1)___, 2)_____, 3)______, 4)_____

19. 1)___, 2)_____, 3)______, 4)_____ **20**. 1)___, 2)_____, 3)______, 4)_____

21. 1)___, 2)_____, 3)______, 4)_____ **22**. 1)___, 2)_____, 3)______, 4)_____

23. 1)___, 2)_____, 3)______, 4)_____ **24**. 1)___, 2)_____, 3)______, 4)_____

Appendix C: Test items

Task one: Syllable Awareness (for the first 10, judge if the first syllables are the same; for the last 10, judge if the second syllables are the same)

1. lōgĭ--lōtŏ 2. lāgĭ--lātŏ 3. lāgĭ--lōtŏ 4. tōlă—gīlŏ 5. tōlă—lōgĭ

6. lōtŏ—lōgĭ 7. gīlă—tōlŏ 8. lōgĭ—lātŏ 9. tōgĭ—tōlă 10. gīlă—gīlŏ

11. gīlŏ—tōlŏ 12. gīlă—tōlă 13. gīlă—tōlŏ 14. lātŏ—lōgĭ 15. lātŏ—gīlŏ

16. tōlŏ—gīlŏ 17. lāgĭ—lōtŏ 18. gīlŏ—tōlă 19. gītŏ—lātŏ 20. lāgĭ—lōgĭ

Task two: Onset Awareness (which one has a different onset)

1. bōu fāo fiū 2. chēi quā chiū 3. bōu biū tuā 4. xāi quō quā 5. tiū tuā fāo

6. xuá xái chéi 7. fáo biú fiú 8. chéi chiú quá 9. biú bóu tuá 10. quó xái quá

11. tuă făo tiŭ 12. chiŭ xăi xuă 13. bŏu făo fiŭ 14. quŏ chĕi chiŭ 15. biŭ bŏu tiŭ

16. quò xài quà 17. tiù fào tuà 18. chiù chèi quà 19. fiù fào bòu 20. quà xài xuò

Task three: Rhyme Awareness (which one has a different rhyme)

1. qōu qō xō 2. tǖn tǖ bǖ 3. xōu xāi qāi 4. fǖn tiā fiā 5. xō xōu bōu

6. tǘn tiá bǘn 7. qó bóu qóu 8. tǘ bǘ tǘn 9. xái qái xóu 10. tiá fiá tǘn

11. qŏu bŏu qŏ 12. tǚn bǚn tiă 13. qŏu qŏ bŏu 14. tǚ bǚ tǚn 15. xăi qŏu qăi

16. tià fià tǜn 17. qò qòu bòu 18. tǜn tià bǜn 19. xò qò qòu 20. bǜ tǜ tǜn

Task four: Tone Identification

Single tones (identify the tone of each item)

1. lō 2. tó 3. lŏ 4. tó 5. lò 6. tó 7. lŏ 8. lŏ 9. ló 10 lŏ 11. lō

12. tō 13. lŏ 14. tò 15. lō 16. tō 17. ló 18. tō 19. ló 20. tŏ

21. lò 22. tò 23. lò 24. tò

Double tones (identify the tone of the first syllable)

1. lōgì 2. tōgǐ 3. lōgī 4. tógí 5. lógí 6. tōgì 7. lógì 8. tògī 9. lógī 10. tógǐ

11. lōgǐ 12. tògǐ 13. lògí 14. tógì 15. lògī 16. tògí 17. lōgí 18. tògì 19. lògǐ

20. tōgī 21. lògì 22. tōgí 23. lógǐ 24. tógī