The Effects of Musical Ability on the Learning of Mandarin Chinese by High School-Aged Students

Word Count: 5000
1. Introduction

1.1. Background

Over the years, an abundance of research has been conducted regarding the topic of music and its relationship with enhanced cognitive function. Topics researched on the benefits of music on enhanced cognition include the possible benefits it presents that could help increase specific measurements such as IQ and test scores. According to Jänke (2012), this research especially surged from the late 2000s to the early 2010s. One relation that is not as well-known involves music and the role it plays in language. Music and language can be compared because both involve auditory processing and cognitive skills and skills for both are acquired at similar ages (Brandt et al., 2012). Consistent with Brandt et al. (2012), a 2010 study suggested that language was a suitable domain to study concerning music as it involves “complex sounds” and shares many cortical (outer layer of the brain) and subcortical (below the outer layer of the brain) areas of the brain (Delogu et al., 2010). Further, results from a 2002 study showed that music proficiency could help predict future language acquisition skills for both first language (L1) and second language (L2) in adult learners (Anvari et al., 2002).

1.2 Tonal and Nontonal Languages

A tonal language is a language that relies on lexical tones to communicate a semantic meaning (Delogu et al., 2006). For example, Mandarin Chinese uses 4 tones characterized each as either high-level in pitch, high-rising in pitch, low-dipping in pitch, and high-falling in pitch (Delogu et al., 2006). These tones are either notated with the number corresponding to the tone, or with a symbol above the vowel in the word. Variations of these tones on the same

words can completely change the meaning. For example, “ma1” means mother, “ma2” means hemp, “ma3” means horse, and “ma4” means to scold (Delogu et al., 2006). Examples of languages that rely on lexical tones include Mandarin, Thai, Vietnamese, Cherokee, but are not limited to Asian languages and include several African languages. Because pitch is important in understanding and speaking these languages, the connection between tonal languages and music is especially relevant. As mentioned previously, domains of the brain concerning both music and language overlap, and with the involvement of pitch in the instance of tonal languages, this overlap is even more evident.

In contrast, a nontonal language does not rely on tones to relay the meaning of specific words but can utilize emphasis and pitch variation to communicate. For example, if asking a question in English, the tone of one’s voice naturally rises, indicating that something is being questioned. Examples of non-tonal languages include English, Italian, and French.

1.2 Purpose and Gap

The purpose of this research is to observe if musical ability—an individual’s musicality, ability to understand music, and/or ability to produce music—has any effect on tonal language acquisition. Because of the overlapping of domains in language and music processing, my research aims to address the question, “Does musical ability improve the learning of Mandarin Chinese by high school students?” Research has been conducted on this topic (Delogu et al., 2006, 2010; Besson et al., 2007, 2011; Carpentier et al., 2016; Swaminathan and Schellenberg, 2020; etc.); however, it appears that only one of the studies that I found (Talamini et al., 2018) studied participants who were close in age (11-14
years old) to the age group that I would be studying, which, as mentioned before, will be ages 14-18. Most studies (Besson et al., 2007, 2011; Brandt et al., 2012; Carpentier et al., 2016; Nan et al., 2018; Sala et al., 2019; Chang et al., 2016) have looked at how musical training affects younger participants (ages 5-8) or adult participants (college students and above) and few attempted to search for a beneficial relationship between musical expertise and language acquisition.

1.3 Possible Implications

Tonal languages are notoriously known for being difficult to learn due to the involvement of specific tones in communication. If my findings support my hypothesis, aspects of music can be implemented in future classrooms when teaching tonal languages. Further, I hope that my research can provide more areas of interest for future research on the same or similar topics.

2. Literature Review

This literature review will consist of information on the existing relationship between music and language, a short explanation of transfer effects followed by a brief section explaining language-to-music transfer, and a more in-depth section describing the music-to-language transfer effect and studies that have come with it.

2.1 Relationship Between Music and Language

From 2000 to the early 2010s, the effects of music and language on each other were popularly researched. To first understand the extent to which music affects the acquisition of tonal languages, it is important to understand how the basic forms of both interact with each other. In one article (Brandt et al., 2012), researchers explain that while language is generally viewed as a key part of human intelligence, music is viewed as something that builds off the ability of language. They argued that instead of being two separate domains, the two can be merged because language is a type of music itself, therefore, a relationship between the two domains can be formed. Furthermore, they brought up the point that any sound can be treated musically because of these similarities.

Another component that music and speech share, according to Brandt et al. (2012), include learning mechanisms. Like language, infants can discriminate between different musical systems as they can discriminate different sounds in language. Infant-directed speech is often more “sing-song” and slower. This can be compared to musical pitches and rhythm, which again, highlights the shared characteristics between the two domains.

In contrast with Brandt et al., an article by Jäncke (2012) mentions that traditionally, music and language were viewed as different psychological functions having no connection to each other, mainly due to the commonly accepted theory that speech functions are more active in the left hemisphere of the brain while music functions are more active in the right side of the brain. The left brain is thought to be more involved in pattern recognition and analytical skills while the right brain is agreed to be more creative and less systematic. However, this belief is now challenged by numerous studies on the relationship between music and languages and vice versa.

2.2 Transfer Effects

The transfer effect in psychology refers to the “ability that individuals can use the knowledge and skills learned in one scenario to achieve different goals in other scenarios” (Weng et al., 2019). The concept of the transfer effect is important to
understand how humans take in and process information. There are two main types of transfer effects: near transfer and far transfer. Near transfer refers to the transfer of knowledge across closely linked domains while far transfer refers to the transfer of skills across more weakly linked domains. In context of brain anatomy, near transfer involves more closely situated brain regions while far transfer involves brain regions situated further apart (Weng et al., 2019). Because of the proximity of brain regions in near transfer, this type of transfer occurs much more frequently than far transfer where brain regions are further apart. Examples of near transfer include learning how to play the viola after previously knowing how to play the violin, while an example of far transfer includes visualizing angles used in geometry to help gauge the angle and distance needed to shoot a ball in basketball.

The understanding of transfer is key to predicting how music will affect tonal language acquisition, as language-to-music transfer is an example of a far transfer.

2.3 Language to Music Transfer

Transfer involving language and music can be studied both ways: how language impacts musical ability and how music impacts language acquisition. When talking about language-to-music transfer, the main ability observed is perfect pitch, more technically known as absolute pitch (AP). AP can be defined as the ability to name or generate a pitch without a reference note (Deutsch et al., 2005). This ability is extremely rare and in Europe, the prevalence of AP in the general population is reported at about 1 in 10,000. Interestingly, this number is much higher in China. From this information, researchers from the University of California, San Diego sought to observe the occurrence of this rare phenomenon in university students. This study compared the prevalence of AP in American and Chinese conservatory students. Results from the experiment revealed that 60% of Chinese musicians met the criteria for AP compared to 14% of American students. Additionally, the findings showed that an individual has a significantly higher chance of developing absolute pitch during childhood training, especially for those who speak tonal languages, with the ones studied being Vietnamese and Mandarin.

2.4 Music to Language Transfer

Music-to-language transfer explores how musical ability interacts with language. A study conducted by Delogu et al. (2009) explored how melodic ability affects the learning of tonal languages by native tonal speakers. Forty-six students with no experience with mandarin were presented with two short lists of spoken monosyllabic Mandarin words and then asked to do a same-different task of identifying if the variation of the word was phonologically or tonally different. Results showed that all subjects were significantly more accurate when determining differences in phonetics rather than tone and participants showing higher melodic ability performed better in detecting tonal variations.

Findings from a similar study by Marie et al. (2010) concluded the same results as Delogu et al (2009). In this study, results showed that musicians could discriminate both tones and segmental variation more accurately than non-musicians. Further, there were lower error rates overall in musicians compared to the error rates of nonmusicians.

The results of these studies strongly suggest that individuals with a higher musical ability, more specifically those who play instruments, are more adept at discriminating between tones in tonal languages due to their training that develops their ability to identify pitch changes.
The articles most abundant on this topic discussed how musical training impacted language acquisition in children ages 4-9. In an article by Swaminathan et al. (2020), 6–9-year-old children were tested to see if music affected their language skills. Language ability was tested through grammar and speech perception and musical expertise was tested through melody and rhythm discrimination as well as long-term memory for music. Results showed that rhythm discrimination was a better predictor of language ability than melodic discrimination. Implications of this study suggest that musical ability is a good predictor of language ability and confounding variables like IQ are independent of this relationship.

Additionally, an article by Nan et al. (2018) showed that piano training enhanced speech and pitch processing in Mandarin-speaking children. In this longitudinal study, 74 4–5-year-old children were split into three groups: a reading training group, a no-contact control group, and a piano training group. Each group trained for 6 months, and results showed that the piano group showed positive mismatch responses (pMMRs) to lexical tone and musical pitch changes. All three groups improved equally on the cognitive level, however.

Interestingly, both Nan et al. (2018) and Swaminathan et al. (2020) found that musical training and ability acted as a strong predictor of language skills in young children. Furthermore, both researchers concluded that the benefits of musical training could help with L2 acquisition. These results further establish the notion that a higher musical ability is beneficial to L2 acquisition.

2.5 Summary
Established in the literature review, both language-to-music and music-to-language transfer are areas of research with much involvement. Many studies have acknowledged the effects of musical ability on tonal language acquisition, with results showing musicians consistently perform better when discriminating varying tones in monosyllabic Mandarin words. Although not a pressing issue, if further connections between music and language can be established, learning languages in classrooms can become more efficient and effective in schools across the country.

3. Methods
This study aims to answer the question “Does Musical Ability Improve the Learning of Mandarin Chinese by High School Students?”

Because of the nature of my proposed research question, a quantitative experimental study was used. The procedure and format of the present study was loosely based on a combination of two foundational studies by Delogu et al (2009) and Marie et al. (2010). Then, self-created word lists that will be explained in greater detail later in the paper were used to measure participants’ ability to accurately identify variations in tone.

3.1 Experiment Method
An experiment is a type of research method that involves the researcher introducing an independent variable and then studying its effects of it on a group. Usually, a hypothesis is made before the experiment and results can be both qualitative and quantitative. In the present study, an experimental design method helped collect quantitative results. An experimental study was deemed best suited for this topic because it allowed for more control of the environment. Additionally, the two foundational studies (Delogu et al. 2009, Marie et al., 2010) utilized an in-person experimental method for their research, so in my own study, I tried my best
to closely replicate the method while also adapting it to fit a high school setting. While an in-person experiment provides such benefits, it also has many limitations, the main one being sample size. In-person experiments often require much more effort from the participants' side, whereas, in a survey, participants simply need to type or select answers. Because of this, I had only a small group of people willing to participate in the present study.

It is also important to mention that initially, I wanted to choose an online survey method for my research, however I quickly realized while creating the template for my experiment that the instructions could be confusing for the participants taking the survey. I reasoned that if the experiment was in person, it would be much easier to clear up any confusions and answer any questions that the participant may have had. Therefore, this was another reason why I settled on an experimental design method for the present study.

3.2 Participant recruitment and requirements

The participants in this study included high school aged musician and non-musician students from a private independent school in Southwest Florida. All participants chose to participate voluntarily.

For my experiment, I separated students into two groups: English-speaking non-musicians and English-speaking musicians. The requirement to be English-speaking is justified by the fact that my research seeks to observe how well native non-tonal speakers can identify tonal variations in spoken, monosyllabic Mandarin words. Participants were between the ages of 14-18, as my target population is high school students.

To recruit participants who were musicians, the rosters of the school's band or orchestra classes were acquired through the music department administrator. The grade level of students in each class ranged from 9th to 12th grade. To acquire more information about their musical and language backgrounds, an email that introduced the study was sent out to a total of 32 students. In this email, a survey link was included. The survey consisted of 5 questions:

- What is your name?
- What grade are you in?
- What type of instrument do you play?
- How long have you been actively playing your instrument?
- Can you read, speak, write, and/or understand Mandarin or any other tonal language (e.g. Vietnamese, Thai, Cantonese)?

After a period of 5 days, 11 responses were collected. Of these 11 responses, one person was omitted because they had answered yes to the last question. Another email was sent to the 10 people who responded. In this email, I informed the students that based on their previous survey responses, they had the opportunity to participate in my study if they wished to do so. I also attached a consent form (refer to Appendix A) as well as a link to a sign-up spreadsheet where students could sign-up for a specific time slot. Out of the 10 students who were emailed, only 4 agreed to participate in the in-person experiment.

The control group was acquired through in-person recruiting based on people I was familiar with for convenience. I made sure that the students from the control group had little to no experience of playing an instrument and no experience of learning tonal languages of any kind. A total of 3 students were recruited bringing the participant total to 7 students.
3.3 Experiment instruments/tools

Spoken samples of monosyllabic words were acquired from an online database called The Chinese Learning Institute. The words used were not the same as the ones from the foundational studies because, in both studies, it was stated that the words used were randomly chosen. This allowed me flexibility in my method to randomly choose and create my own word lists as no specific criteria was required for the word lists.

3.4 Procedures

Before starting the experiment, my procedure was approved by my school's IRB, and consent forms were signed by both parents and students. Upon arriving at the designated meeting location at their selected time, students were given a brief introduction of the study once more. Then, I familiarized them with Mandarin tones to prepare them for the main procedure. Once familiarized, students were informed of the experiment procedure. Then, they were played recordings of lists that contained monosyllabic Mandarin Chinese words. The first list they listened to was the testing list. This list contained anywhere from two to four monosyllabic Mandarin words. Following this list was the test list. The test list would either remain the same as the testing list, or it could differ with only the tone of one word changing. Students were then asked to identify if the test list differed from the testing list, and if it had changed, which item in the list had varied in tone. Both foundational studies (Delogu et. al, 2006; Marie et. al, 2010) tested around 150 words, however, for the sake of time, I abbreviated my procedure to include a total of 56 words organized into 15 listening-test lists (refer Appendix C). Below are examples of differing and unchanged lists. Numbers next to the words indicated the tone of the word (e.g., re2 is the word “re” spoken with the second tone):

- Differing lists
  - Listening list
    re2/zuo1/dai2/fei1
  - Test list
    re3/zuo1/dai2/fei1

- Unchanged lists
  - Listening list
    re2/zuo1/dai2/fei1

Students were given an answer sheet to mark their responses, as seen in Figure 1. To see the full answer sheet, refer to Appendix B.

Figure 1

1. Did the test list differ at all from the listening list in tone?
   Yes  No

If yes, which item in the test list differed in tone?

1 2 3 4

On average, the procedure lasted around 10-12 minutes.

3.5 Data analysis

Quantitative data was collected in the form of percentage correct. Scores were calculated by taking the percent correct out of the total 15 list pairs. Since the sample size was too small to perform any type of statistical significance test, the averages of the control and experimental groups were compared. The data was then presented in a bar graph so any discrepancies among the averages of the two groups could be visually seen.
4. Results and Discussion

This experiment aimed to observe the effect of a musical ability on the learning of Mandarin Chinese in high school students aged 14-18. In this section, the participant's background will be given, then the results of the experiment will be discussed as well as presented graphically. Statistical significance was not tested since the minimal sample size to test for statistical significance is 30, and I only received 7 responses. Finally, before discussing results, it is important to mention that my initial assumption going into this experiment predicted that students who played an instrument and had formal musical training would more accurately identify tonal variations in Mandarin Chinese than students who did not play because the musicians' trained pitch recognition and detection would be superior to the non-musicians' pitch recognition and detection ability.

4.1 Participants

Students part of the experimental groups were referred to as Students A, B, C, and D (see Table 1). Students part of the control group were referred to as Students E, F, G (see Table 2).

While the age and grade level variation seen throughout the participants is not very diverse, this was not an issue in my experiment because the foundational study (Delogu et. al, 2006) that I based my method off clearly stated that age and gender had no impact on the results. Therefore, these aspects of the participants were not accounted for while analyzing results.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Instrument</th>
<th>Years Played</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student A</td>
<td>11th</td>
<td>Piano</td>
</tr>
<tr>
<td>Student B</td>
<td>11th</td>
<td>Flute</td>
</tr>
<tr>
<td>Student C</td>
<td>11th</td>
<td>Guitar</td>
</tr>
<tr>
<td>Student D</td>
<td>12th</td>
<td>Piano</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grade Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student E</td>
</tr>
<tr>
<td>Student F</td>
</tr>
<tr>
<td>Student G</td>
</tr>
</tbody>
</table>

4.2 Findings and results

Participants were split into two groups: English-speaking musicians and English-speaking non-musician. The musician group acted as the experimental group while the non-musician group acted as the control group. After student responses were analyzed, results showed that the experimental group, on average, correctly identified tonal variations around 53.3% of the time and the control group, on average, correctly identified tonal variations around 73.3% of the time. These results are shown in Figure 2.

![Figure 2](attachment:image.png)
Before going in depth about the results, it is important to know that two types of error based on Delogu et al. study (2006) was considered in the data analysis:

- Incorrect or missing identification of tonal variations
- False identification of a tonal variation (sequences are the same but a tonal variation is identified)

4.2.1 *Experimental group findings*

After grading responses to an answer key (Appendix C), students were scored on accuracy out of 15. Both Student A and B scored a 10/15. Interestingly, when A and B correctly identified a pair sequence that differed in tone as well as the correct item it differed in, the tone comparisons always included either the first tone or the fourth tone. The most missed sequences were the sequences that differentiated between the second and third tones. These sequences were missed due to missing identification of a tonal variation. This means that both Students A and B failed to recognize a difference when listening to the sequences that contained tone differences between these tones.

The next most common error was a missing identification. For three out of the five incorrect identifications, both Student A and B answered that the sequences did not change even when change occurred.

Although it did occur, incorrect identification was the least common error among the answers of Student A and B. 1 out of 5 incorrect responses for Student A and 0 out of 5 responses for Student B were due to incorrect identification of a tone, meaning the sequence was correctly identified as differing, however, the item of the sequence was incorrectly identified.

Unexpectedly, Student C and D performed significantly worse than Student A and B, with scores of 8/15 and 7/15 respectively. The most common type of error among these two students were false identification of tones with both students falsely identifying tones from 3 out of the 4 unchanged sequences pairs.

The low scores produced by all for students were unexpected and contradicted my initial assumptions. During the experiments, all students remarked the difficulty of the test. Because I also informed them to answer as quickly as possible, this could have added pressure to them and caused them to randomly guess, therefore leading to their lower scores. Moreover, during the procedure, many of the musician participants changed their answers. I noticed that they seemed more set on getting answers right rather than providing me with their initial, most authentic response. These observations allowed me to theorize that because musicians had the musical training that developed their abilities to become familiar with pitch changes, many of them might have overthought their answers, leading to them second guess their original answers, thus scoring lower.

4.2.2 *Control group findings*

Like the experimental group, the control group’s responses were scored based on accuracy out of 15. Surprisingly, Student F scored 11/15, Student G scored 10/15 and Student H scored a 12/15. When compared to the experimental group, Students F and G made almost the same errors as the experimental group. The sequences correctly identified were the sequences that did not vary in tone and the sequences that varied in comparisons between the first and fourth tones. As found in the experimental group, comparisons between the second and third ones were the most missed.

The anomaly of my experiment was Student H who scored the highest among both the control and experimental group. This contradicted my initial assumption that
musicians would score higher than non-musicians. Additionally, among both the control and experimental groups, Student H was the only participant who correctly identified every sequence pair that compared the second and third tones, which are notoriously known to be the harder tones to identify between.

The unexpectedly high scores produced by the control group could have been because the control participants did not experience the same uncertainties that the experimental group had due to their overall lack of musical training. In turn, this could have allowed them to answer with less hesitance, resulting in no changing of answers or second guessing that could have caused scores to potentially fall.

4.3 Comparing with previous studies

As I initially stated, the results produced from my experiment rejected my hypothesis that musicians would score higher than non-musicians while discrimination between tonal variations. In both Delogu et. al (2006,2009) studies, participants who displayed higher melodic ability always, on average, scored higher than participants who displayed lower melodic ability. In both 2006 and 2009, Wing’s Standardized Tests of Musical Intelligence. Additionally, in Marie et. al’s (2010) study, music conservatory students with higher melodic ability also scored higher when discriminating between tonal variations than students with lower melodic ability. However, the results of my study showed that the control group (non-musicians) scored higher than the experimental group.

5. Conclusion

This study explored the effects of musical ability on the improvement of learning Mandarin Chinese by high school students. This was explored using an experimental research design where students were separated into two groups, and their ability to discriminate between tonal variations was tested. Additionally, the present study filled the demographic gap in this topic of research, as high school aged participants had not previously been the target of this type of experiment and added to this field of research. The results, however, contradicted my initial hypothesis and musicians unexpectedly scored much lower on average compared to the control group.

5.1 Limitations

Like any study, many limitations were factored into my results as I was analyzing my data. The first major limitation was the lack of participants. As mentioned before, the present study only included an extremely small sample size of 7 participants. This number hindered the accuracy of my data. With a larger sample size, a more representative set of data could be considered. Moreover, the uneven participant number for each group skewed my results as I was taking the averages. The next limitations considered were the limitations of my method. In the foundational study, Delogu et. al (2006), 5 blocks of 18 listening-test lists were administered while in my experiment, only one section of 15 listening-test lists were administered. The overall lack of data collected compared to Delogu et. al could also have skewed my results. Moreover, in Delogu et. al’s study, melodic ability was tested using a subtest of Wing’s Standardized Tests of Musical Intelligence. In my experiment, I did not test melodic ability and instead assumed that students who played instruments would display higher melodic ability than students who did not play instruments. However, this assumption could have been incorrect seeing as my results showed that the control group
(non-musicians) overall scored higher than the musicians.

5.2 Implications and future research

Although my results did not confirm my hypothesis and did not align with the results of the foundational studies (Delogu et al., 2006; Marie et al., 2010), they did reveal a notable finding on the topic as well as an interesting new inquiry of research. The results of my study could have been because my participants were adolescents. The adolescent brain is not as elastic as the pre-adolescent brain and a professional musician has much more experience than a high school musician. Put together, because a high school student musician’s capacity to learn languages is not at it’s peak and the musical experience that they have is not as sharpened and trained as an adult professional musician, these reasons are a possibility as to why results were unexpected. Because of the reasons above, my results suggest that if music is a sought-out method for improving foreign language learning, then it should be implemented before adolescence. However, further research on this topic must be conducted before confirming this conclusion.

The new inquiry of research arose from the surprising results from the highest scoring participant. Student H mentioned that although they didn’t have any formal musical training, they were an avid listener of music. This led me to make a new connection between musicians and melodic ability. Although it appears that no study has mentioned this, the musical ability of an avid music listener could be studied against the musical ability of a trained musician. Results could show that learning an instrument is not entirely necessary to benefit from the relationship between music and language. However, since only one participant reported that they were an avid music listener and scored higher than the
References


Appendix A

CONSENT FORM

You are being asked to be in a research study. The name of this study is “Mandarin Tonal Discrimination in Musician and Non-Musician Students.” This study is being conducted by X, an AP Research student at X.

What is the purpose of this study—what is it trying to learn?
The purpose of this study is to observe students’ ability to discriminate and recognize different tones in Mandarin Chinese.

Why is this study important—what good will the results do?
This study is important because it could help Mandarin Chinese be better implemented into school systems and other foreign language programs. It could also provide data and a reference study for future research experiments that are similar.

Why have I been asked to be in this study?
You have been asked to be in this study because you are either:

a) a student who cannot speak or understand Mandarin Chinese or any other tonal language (e.g., Cantonese, Vietnamese, Thai) and you do play an instrument

b) you are a student who cannot speak or understand Mandarin Chinese or any other tonal language (e.g., Cantonese, Vietnamese, Thai) and you do not play an instrument.

What will I be asked to do in this study?
You will be asked to listen to pairs of monosyllabic Mandarin words and record how you think the second pair word differed from the first word in tone.

How much time will I spend in this study?
The estimated time to complete this experiment ranges from 10-15 minutes.

What are the benefits of being in this study?
The benefits include increasing your knowledge on a foreign language and helping towards the purpose of my research study.

What are the risks (dangers or harm) to me if I am in this study?
There are no risks for being in this study. All the data collected will remain anonymous.

How will my privacy be protected?
The names of the students will be kept confidential to everyone except the researcher. Only the researcher will have access to the data. The school and students will not be identified in the paper.

If I don’t want to be in the study, are there other choices?
If you do not want to be in this study, you have the right to not consent. You can opt out of this study at any time.
What if I have questions, suggestions, concerns, or complaints?
If you have questions or concerns later, you can reach me at [redacted]. If you have any questions about your rights as a research participant, you may contact X the AP Research teacher, at X.

I have read this consent form. I have had a chance to ask questions.

_____________________________ Date________
Signature of Research Participant

_____________________________ Date________
Signature of Parent

Appendix B
Student Answer Sheet

Please answer all questions to the best of your ability and as quickly as possible. Please circle your answers.

1. Did the test list differ at all from the listening list in tone?
   
   Yes  No

   If yes, which item in the test list differed in tone?
   1  2  3  4

2. Did the test list differ at all from the listening list in tone?
   
   Yes  No

   If yes, which item in the test list differed in tone?
   1  2  3  4

3. Did the test list differ at all from the listening list in tone?
   
   Yes  No

   If yes, which item in the test list differed in tone?
   1  2  3  4

4. Did the test list differ at all from the listening list in tone?
   
   Yes  No

   If yes, which item in the test list differed in tone?
   1  2  3  4

5. Did the test list differ at all from the listening list in tone?
   
   Yes  No

   If yes, which item in the test list differed in tone?
   1  2  3  4

6. Did the test list differ at all from the listening list in tone?
Yes  No

If yes, which item in the test list differed in tone?

1  2  3  4

7. Did the test list differ at all from the listening list in tone?

Yes  No

If yes, which item in the test list differed in tone?

1  2  3  4

8. Did the test list differ at all from the listening list in tone?

Yes  No

If yes, which item in the test list differed in tone?

1  2  3  4

9. Did the test list differ at all from the listening list in tone?

Yes  No

If yes, which item in the test list differed in tone?

1  2  3  4

10. Did the test list differ at all from the listening list in tone?

Yes  No

If yes, which item in the test list differed in tone?

1  2  3  4

11. Did the test list differ at all from the listening list in tone?

Yes  No

If yes, which item in the test list differed in tone?

1  2  3  4
12. Did the test list differ at all from the listening list in tone?
   Yes  No
   If yes, which item in the test list differed in tone?
   1 2 3 4

13. Did the test list differ at all from the listening list in tone?
   Yes  No
   If yes, which item in the test list differed in tone?
   1 2 3 4

14. Did the test list differ at all from the listening list in tone?
   Yes  No
   If yes, which item in the test list differed in tone?
   1 2 3 4

15. Did the test list differ at all from the listening list in tone?
   Yes  No
   If yes, which item in the test list differed in tone?
   1 2 3 4

Appendix C
Answer Key to Student Response Sheet

Sequence 1: same
Die1/ma1
Die1/ma1

Sequence 2: different
Ta2/bie4
Ta2/bie1

Sequence 3: different
Re2/zuo1/la4
Re1/zuo1/la4

Sequence 4: same
He3/guo1/shu3/ti4
He3/guo1/shu3/ti4

Sequence 5: different
Huo4/tiao1/jia3
Huo4/tiao4/jia3

Sequence 6: different
Xiao3/mao1/ru4
Xiao3/mao1/ru3

Sequence 7: different
Wei1/pao2
Wei1/pao3

Sequence 8: same
Zhu3/duo1/che2
Zhu3/duo1/che2

Sequence 9: different
Sheng4/mai1/tie3/luo4
Sheng4/mai2/tie3/luo4

Sequence 10: different
Bai2/yuan2
Bai3/yuan2

Sequence 11: same
Hen3/song1/dai4
Hen3/song1/dai4

Sequence 12: different
Jiao1/qiao1/ren3
Jiao4/qiao1/ren3

Sequence 13: different
Gua2/ruo4/sui4/suo1
Gua2/ruo3/sui4/suo1

Sequence 14: different
Kuo2/duo1/nong2/can1
Kuo2/duo1/nong4/can1

Sequence 15: different
Yong3/fu4/mu4
Yong2/fu4/mu4