Intonation Patterns of Declarative Questions in Mandarin Conversational Speech

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Bachelor of Arts in Linguistics

Haverford College

May 2023

Abstract

This thesis investigates the intonation patterns of declarative questions in Mandarin conversational speech. Using a natural speech corpus, we explore the use of rising intonation in different types of declarative questions and examine the specific tonal adjustments made to sentence-final syllables. Our findings suggest that the proportion of rising intonation in assertive and inquisitive declarative questions is similar. We also conduct an experiment on production of rising intonation in scripted conversations. Results show that declarative questions have an overall higher pitch than their statement counterparts, and rising intonation is frequently adopted by speakers at the end of declarative questions. Furthermore, rising intonation modifies the tonal contour of sentence-final syllables depending on the lexical tone. This study contributes to our understanding of the interplay between tone and intonation in Mandarin conversational speech and provides foundation for further research on the intonation pattern of different types of declarative questions.

Acknowledgement

I would like to express my gratitude to my thesis advisor, Professor Jane Chandlee, for her invaluable guidance and constructive feedback that helped me navigate through the thesis process. I am also grateful to Professor Jonathan Washington for serving as my second reader and providing valuable insights that enhanced the quality of my work.

I would like to extend my sincere thanks to my family for their unconditional love and encouragement throughout my academic journey. Their support made it possible for me to pursue my passion in linguistics. I am also grateful to my friends for providing inspiration and companionship that helped me overcome challenges and stay motivated throughout my thesis process.

Contents

1. Introduction

Phonetic and perceptual experiments have consistently revealed an intriguing link between intonation and sentence modalities such as statement and question. This relationship is manifested across different languages, where questions are commonly characterized by a rising pitch contour while statements feature a falling pitch contour. Declarative questions are sentences formed as statements, but executing an interrogative function in a discourse.

In Mandarin, a tonal language, fundamental frequency (F0) serves as the acoustic cue for both lexical tones and sentence intonation. Following the discussion in previous literature on the distinction between declarative question intonation and statement intonation in read speech in Mandarin, this thesis investigates the intonation patterns of Mandarin declarative questions in a natural conversational setting. In particular, we focus on the use of rising intonation in different types of declarative questions and investigate the specific tonal adjustments made to sentence-final syllables. This investigation is essential as it may have practical implications in prosodic assignment for speech technologies. Furthermore, it could also provide theoretical contributions to our understanding of the interplay between tone and intonation in a natural speaking environment, which exhibits more variability in the way sentences are produced.

Using a natural speech corpus in Mandarin, this study analyzes the frequency of rising intonation in declarative questions. Additionally, we conduct a phonetic analysis on recordings of six Mandarin-speaking college students studying in the United States to examine their production of rising intonation in target declarative questions while reading and acting out scripted conversations.

The structure of this thesis is as follows: Section 2 introduces different question types in Mandarin and the relationship between tones and intonation; Section 3 states the research questions and hypotheses; Section 4 introduces the research methods used in the corpus data

analysis and experiment analysis; Section 5 presents the findings from the collected data; Section 6 discusses the results and concludes the thesis.

2. Background

This section provides an overview of the syntactic structure and the function of different types of questions in Mandarin (2.1), which we based our working definition of declarative questions on. We also discuss the pragmatic functions of declarative questions and hypotheses in previous literature that proposes a correlation between the type of declarative question and their respective intonation patterns.

2.1 Question Types in Mandarin

Mandarin has four common types of questions, overviewed in (2)-(5) with examples selected from Yuan (2005).

(1) Statement:　　　　他 想　去.
　　　　　　　　　　he want go
　　　　　　　　　　"He wants to go."

(2) Yes-no question:　他 想　去 吗?
　　　　　　　　　　he want go QST
　　　　　　　　　　"Does he want to go?"

(3) Echo question:　　他 想　去?
　　　　　　　　　　he want go
　　　　　　　　　　"He wants to go?"

(4) A-not-A question:　他 想　不　想　去?
　　　　　　　　　　He want not want go
　　　　　　　　　　"Does he want to go or not?"

(5) Wh-question:　　他为什么 想 去?
　　　　　　　　　　he why want go
　　　　　　　　　　"Why does he want to go?"

Example (1) is a typical declarative sentence in Mandarin, which follows the Subject-Verb-Object word order. Sentences (2) - (5) are different ways to form questions based on the information entailed in statement (1). Example (2) is a yes-no question, also known as a polar question. While polar questions in English are characterized by word order inversion, Mandarin polar questions are commonly constructed by adding the particle *ma* to the end of its statement counterpart. Example (3) is an echo question, which has the same sentence constituents and word order as (1). However, in a conversation, the content of an echo question essentially duplicates the preceding declarative sentence, and the primary function of an echo question is to restate and question the preceding statement. An echo question in Mandarin is typically marked by a rising intonation at the sentence boundary, as noted by Xu (2016). It is worth noting that we consider echo questions a form of declarative question in the context of our research, but declarative questions are not limited to echo questions, and repeating the preceding statement verbatim is not mandatory. Example (4) illustrates the A-not-A question type, which is formed by reduplicating the main verb A using *bù* 'not' or *méi* 'not yet', i.e. A-*bù*-A or A-*méi*-A. Sentence (5) is an example of a wh-question, which seeks specific details from the addressee, such as 'where', 'what', and 'why'. Since Mandarin Chinese is a wh-in-situ language (Huang, 1982), wh-words such as *shénme* 'what', *wèishénme* 'why', *nǎ* 'where', etc. remain at their base positions. In response to the aforementioned question types, speakers usually use yes or no to answer questions like (2) and (3), the verb A, or not A, to answer type (4), and specific information corresponding to the wh-word for type (5).

The above categorization of question types in Mandarin provides a framework for us to define the scope of declarative questions in our study, which will enable us to identify relevant instances in the corpus data, as described in Section 4.1, and to construct conversations for the

experiment. In the following section, we provide a more detailed account of previous studies on the pragmatic functions and prosody of declarative questions.

2.2 Declarative Questions

Declarative questions are sentences formed as statements, but executing an interrogative function in a discourse. There are different dimensions to understanding this mismatch in form and function. Applying the notion of discourse Common Ground[1] (Stalnaker, 1978), Gunlogson (2003) claims that English declaratives with a falling intonation commit the speaker to their propositional context, whereas a sentence-final rising intonation commits the addressee to the expressed proposition. Example (6) demonstrates the difference in speaker commitment in a polar question (6a), a declarative question (6b), and declarative statement (6c).

> (6) a. Is shoplifting fun?
>   b. Shoplifting's fun?
>   c. Shoplifting's fun.

Questions (6a) and (6b) presuppose that the addressee is knowledgeable about the experience of shoplifting and capable of offering a judgment. These questions do not reveal information about whether the speaker has shoplifted, whereas (6c) implies that the speaker is the source of information and may have personal experience with shoplifting. This leads to the difference in the speaker commitment of the information entailed by the sentence; although both (6b) and (6c) are produced by the speaker, the former conveys additional information about the addressee's knowledge, while the latter conveys additional information about the speaker's experience. In terms of why declarative questions are used by speakers in conversations, Levinson (2012) suggests that speakers try to reduce paying social cost in a conversation. When a speaker seeks

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[1] There is a set of mutual beliefs shared by the discourse participants.

information from the addressee, the level of specificity in the information requested can affect the social cost. More specific requests, such as wh-questions, often require a higher social cost to the speaker. However, declarative questions, which are information-dense and seek only confirmation, can be used as a politeness strategy to make requests in a less confrontational manner. This can help to reduce the social cost to the speaker while still achieving their communicative goal.

Declarative questions have been studied in other languages in terms of their form and functions. For example, a study on Polish student conversations (Chłopicki, 2019) suggests that declarative questions in Polish are marked by the lack of the polar question particle *czy*, the presence of rising intonation, and other question-related particles. Although declarative questions are signaled by sentence-final rising intonation in English and Polish, other languages have shown dissimilar intonation patterns. In a corpus study of Dutch telephone dialogues, Beun (1988) examined how subjects sought information from an information clerk at Amsterdam airport. The study identified 77 declaratives in 189 dialogues, of which only 48% had rising intonation at the end. In a follow-up judgment experiment, participants were able to correctly identify over 90% of the declarative questions as performing an interrogative function based solely on textual cues. This suggests that rising intonation is not mandatory for the formation or recognition of declarative sentences in Dutch.

Building on previous work on declarative questions in English (Gunlogson, 2003; Malamud & Stephenson, 2015; Farkas & Roelofsen 2017), Jeong (2017) proposed two subcategories of rising declaratives, namely inquisitive and assertive rising declaratives. According to Jeong, the speaker is not committed to the proposal in inquisitive rising declaratives (examples 7a-c), whereas they are in assertive rising declaratives like (7d-e) shown below.

(7) Inquisitive Rising Declaratives

  a. Contradictory Questions

      A: John has a sister. We should invite her too.
      B: *John has a sister*? (No way. You must be thinking of his young brother.)

  b. Incredulous Questions

      A: John went to the airport to pick up his sister.
      B: (What?) John has a sister?

  c. Confirmative Questions

      (A is giving tips to B, who needs to interview a female relative of a friend)
      A: You should talk to John. He has a few female members in the family.
      B: (Aha!) *John has a sister?*

  Assertive Rising Declaratives

  d. Unsure about a metalinguistic issue

      A: Do you know if John has any female relatives?
      B: (Um...) *John has a sister?*

  e. Uptalk (politeness; building rapport; eliciting uptake)

      A: Tell me about John's family.
      B: *John has a sister?* (But no other siblings? He's quite close to her?)

Experimental results from Jeong suggest that inquisitive rising declaratives and assertive rising declaratives differ in their intonation patterns in English. Steeper rising slopes at the end of a sentence are significantly more likely to signal inquisitive rising declaratives, whereas weaker rising slopes are significantly more likely to signal assertive rising declaratives. However, a recent study (Goodhue, 2021) undermines this strict form-meaning correlation by showing counterexamples of English inquisitive rising declaratives that have shallow final rise. Goodhue's study highlights the importance of adopting a more nuanced approach when analyzing the intonation patterns of rising declaratives, one that takes into account both conventions and pragmatics.

With respect to declarative questions in Mandarin, many studies (Peng et al., 2005; Yuan, 2006; Zent et al., 2004) focus on investigating the intonational patterns of the different question

types outlined in (2) - (5) in Section 2.1, paying particular attention to the distinctions between questions with and without the question particle *ma*[2] in read speech. However, until recently, there has been limited research on the form and function of Mandarin declarative questions in a discourse context. A recent study by Xie (2021) identified three distinct functions of declarative questions in Mandarin conversational speech using interview videos - seeking confirmation, providing explanation, and topic opener. Using Jeong's categorization, declarative questions that seek confirmation in Xie's analysis covers questions like (7b) and (7c), which belongs to inquisitive rising declaratives, and the second function show similarity to assertive rising declaratives, which can be used to express uncertainty about a metalinguistic issue like (7d) or elicit uptalk as in (7e).

With respect to the intonation patterns of declarative questions, contrary to the previously established belief that declarative questions in Mandarin are typically formed with rising intonation, Xie's study introduces a new perspective. According to Xie, while rising intonation can indeed be used to form questions in Mandarin, his study focuses exclusively on declarative questions that utilize falling intonation, and revealed that declaratives without a rising intonation can also be interpreted as questions by the addressee. Xie's novel approach adds significant value to the existing body of research by incorporating interactional linguistics factors that were previously overlooked. Moving forward, we delve into greater detail regarding the interplay between lexical tones and intonation for different types of questions in Mandarin.

2.3   *Interaction between Question Intonation and Tones*

Since Mandarin is a tonal language, both the lexical tone and the phrase-level intonation are realized by the fundamental frequency. Thus a comprehensive discussion of intonation

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[2] A more detailed account of the intonational differences will be provided in Section 2.3

patterns cannot be made without discussing lexical tones in tandem (Zeng, 2004). There are five lexical tones in Mandarin, i.e. the high-level tone ‘ ¯ ’ , the rising tone ‘ ´ ’, the low tone ‘ ˇ ’, the falling tone ‘ ` ’, and a neutral tone (Chao 1968).

Previous perception experiments revealed that the information of the sentence type is mainly carried by the last one or two syllables in the final prosodic word (Lin, 2004). A followup study by Yuan (2006) suggests that question intonation has an overall higher pitch contour (shown in Figure 1) and a higher pitch strength in sentence final tones than statement intonation.
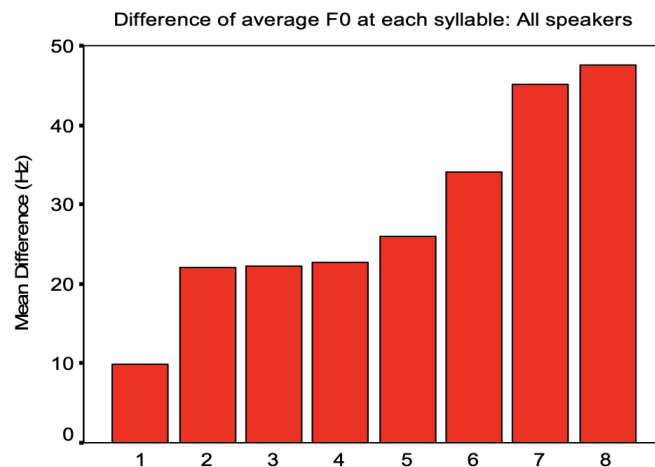

Figure 1: Difference of the average F0 over each syllable pair (question minus statement) for all speakers from Yuan (2006)

Although not stated explicitly by Yuan, the reading materials used in his experiment consist of statements and questions with identical lexical items, which makes the questions declarative questions in the context of our study. Therefore, his observations provide a reference point for comparing the intonation patterns of declarative questions and statements, which is essential to our study. Prior to this study, Zeng et al. (2004) investigated the impact of different modalities on intonation and tones in Mandarin. The study examined three modal variations: (1) declarative, (2) interrogatives with question marker *ma*, (3) interrogatives without *ma* (referred to as "rhetoric question" in the study). Five Mandarin speakers read 72 sentences of various

lengths, covering all four tones as the ending syllable in three modalities. Analysis of the recordings have similar findings to Yuan in terms of the overall phrase curve: the interrogative sentence tones (modal type 2 and 3) have a higher register than in declarative counterparts, with the highest in type 3. In addition, the tonal realizations in the final syllable were modified significantly by interrogatives. The pitch contour of the high tone changes from flat to ascending, the rising and falling tones shift higher, and the descending slope of the falling tones are realized with a less steep descending slope.

Previous experimental data have shown that declarative questions typically have a higher phrase curve than statements, and that rising intonation in questions influences differences in the tonal slope of the final syllable. Despite these findings, there is still much to be understood about the relationship between the intonation of declarative questions and lexical tones in conversational speech. To bridge this gap, I conducted an investigation into the ways in which intonation and lexical tones interact in the context of conversational declarative questions. Building on the insights gained from previous discussions, I raise the following research questions:

3. Research Questions

1. Do speakers use rising intonation to signal declarative questions in Mandarin conversational speech?
   If question 1 is substantiated, then we further investigate whether the type of declarative question, assertive or inquisitive, will affect the usage of rising intonation.
2. How does the intonation pattern of declarative questions in Mandarin conversational speech differ from the corresponding statement form?

3. How does the intonation pattern interact with the lexical tone of the phrase-final syllables in declarative questions?

4. Research Design and Methods

To investigate the intonation patterns of declarative questions in Mandarin within conversational settings, I conducted a two-part analysis that included natural speech and scripted conversations performed by participants. The first data source utilized was the MagicData-RAMC Corpus, which provided conversational speech samples. The second data source consisted of recordings of participants reading scripted dialogs that included declarative questions. Using the corpus data, our initial investigation focused on exploring the correlation between rising intonation in declarative questions and their interactive function types. Based on our findings in Section 5.1, we found that differentiating the specific category of declarative question did not significantly impact the use of rising intonation. Therefore, in the second part of our analysis, we focused on analyzing the intonation patterns and final syllable tone adjustments uniformly without categorizing the declarative questions into two types, enabling us to find a generalization of the intonational features of Mandarin declarative questions.

4.1 MagicData-RAMC Corpus

The MagicData-RAMC Corpus contains 180 hours of conversational speech data recorded from native speakers of Mandarin Chinese (Yang. et al., 2022). This dataset was collected to support speech-related research, including but not limited to speech recognition, topic detection, etc. The dialogs cover topics like daily life, technology, entertainment, etc. The diverse domains covered by the conversational data provide different contexts where declarative questions might appear. In addition, this corpus has rich and high quality annotations, including

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disfluencies, emotional speech, sentence punctuations, etc, which makes locating declarative sentences through the transcripts possible.

Expanding on the framework of question types and functional categories of declarative questions introduced in Section 2, we identified declarative questions in the MagicData-RAMC corpus using the following criteria. Declarative questions have the same syntactic structure as statements and cannot be categorized using one of the question types in Mandarin illustrated in (2) - (5): they do not contain the question particle *ma,* the A-not-A form, or wh-words. In the conversational context, we look for declarative questions that perform the different functions outlined in examples (7a)-(7e). In terms of the addressee's response, they can confirm, negate, or supplement the information provided in response to the declarative question.

To identify the pragmatic function of each declarative question in the dataset and its corresponding declarative question type, we examined its context and recorded whether it should be categorized as an assertive declarative question or an inquisitive declarative question. Additionally, we used Praat to analyze the pitch contour and applied personal judgment to determine whether rising intonation is present in the declarative question. The following instances provide an overview of how we evaluated each instance we identified:

(8) Inquisitive Declarative Question

A:　在家我妈也做过可好吃呢。
My mom also made it at home, and it tastes delicious.
B:　你妈也可以给你做？
Your mom also makes it?
A:　嗯。
Yes.

(9) Assertive Declarative Question

A:　反正我暑假的时候就是玩这个（游戏），在等的时候。
That's what I play during the summer break anyways, while I was waiting.
B:　意思是你那会儿暑假在那儿给人家切了菜之后，然后还得洗碗**?**

You mean that back in summer break, you have to do the dishes after chopping the ingredients?

A: 对。

       Yes.

In example (8), Speaker B echoes the statement made by A, albeit not in the same words. It is unclear from the context whether Speaker B is expressing surprise, incredulity, or merely habitually repeating A's statement. However, Speaker B does not introduce any new information and merely restates A's statement. In (9), the context is that speaker A is talking about a game she's playing while waiting at her work place, and speaker B offers a potential explanation to attempts to elicit uptake from the addressee to account for the waiting time mentioned by speaker A, which makes it an assertive declarative question.

Once the declarative questions wee identified and labeled, we counted the number of instances in each functional category and calculated the proportion of each that had rising intonation. Then, we performed a two-sample proportion test to analyze whether there's a correlation between the intonation pattern and the type of declarative question.

4.2 Experiment Design[3]

4.2.1   Participants

Six college students studying in Philadelphia were recruited through personal connections to participate in the study. The participants consist of 4 female speakers and 2 male speakers, who are native speakers of Mandarin and learned English as their second language. Two of the participants are fluent in other Chinese dialects, but they spoke Putonghua[4] during the interview.

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[3] This project was granted exempt status by Haverford College's IRB board.

[4] Official standard Chinese language used in Mainland China

4.2.2 Experiment

At the beginning of the interview, the participants were asked to familiarize themselves with a script that is provided and then perform it with the interviewer. The script[5] contains dialogs constructed using sentences adapted from the MagicData-RAMC Corpus. For each interactional function of a declarative question, we used four different scenarios with the target sentence ending in four lexical tones[6]. The script reading was recorded for each participant and the data was used in comparison to recordings collected in the second part of the interview. For the second part of the interview, the participants were provided with the list of target declarative questions in their statement form and asked to read the sentences. Example (10) demonstrates how the pair of declarative sentences in different modalities is elicited in the two parts of the experiment. This design is used to compare the speakers' production of declarative question intonation in a context-free scenario.

(10)   Part one

A: 张三邀请我们下周去参加他的生日派对。

A: Zhangsan invites us to his birthday party next week.
B: 他的生日在下个星期天？
B: His birthday is next Sunday?
A: 对。
A: Yes.

Part two

他的生日在下个星期天.
His birthday is next Sunday.

After the recordings were collected, we segmented the sentences in the transcript by syllable and used a Chinese Forced Aligner[7] to align the transcript with the recordings. The TextGrid files

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[5] See Appendix
[6] We decided not to cover sentences with ending syllables that are of neutral tones. We use the findings in the previous study by Zeng et al. (2004) as a benchmark.
[7] Forced aligner code by Jiahong Yuan, the instructions for using the aligner are provided on this website: https://www.ling.upenn.edu/courses/ling521/NewAligner1b.html.

produced by the forced aligner were then manually reviewed to detect any errors. After the alignment, the mean fundamental frequency (F0) of the vocalic portion in each syllable interval was extracted and recorded. Then we calculated the mean F0 difference of each syllable between the declarative question in part one of the declarative statement in part two, which served as an indicator of the overall pitch contour difference. To investigate how the intonation of declarative questions influence the tonal realization contour of a sentence's final syllable, we extracted the pitch listings of the final syllable using a sampling rate of 100 Hz, and normalized the F0 values for the six speakers. A third degree polynomial regression was performed using each speakers' F0 values to obtain an approximation of the pitch contour.

5. Results

5.1. Results from Corpus Data

We examined 111 conversations from the MagicData-RAMC Corpus, covering an audio length of approximately 54 hours. Out of these recordings, we found 65 declarative question instances that satisfy our criteria outlined in Section 4.1. Among these instances, 39 instances are inquisitive declarative questions, and 26 are assertive declarative questions. Table 1 below shows the number of instances in each category and the corresponding number of examples that employ rising intonation.

	Number of Instances	Rising intonation
Inquisitive DQ	39	20
Assertive DQ	26	10

Table 1. Declarative question instances in MagicData-RAMC Corpus

To address our first research question, we analyzed the use of rising intonation in both inquisitive and assertive declarative questions. We found that the proportion of rising intonation was 51.28% in inquisitive declarative questions and 38.46% in assertive declarative questions. To determine if this difference was statistically significant, we conducted a two-tailed two-sample proportion test. The resulting z-score was 1.0157 with a p-value of .30772 > 0.05, indicating that there is no statistically significant difference in the use of rising intonation between the two types of questions. Therefore, based on the declarative question instances that we found in the corpus, our analysis suggests that rising intonation is not employed differently to signal different types of declarative questions. Based on this finding, we decided to treat both types of declarative questions uniformly in the experiment design and data analysis in the second part of the study and focus on generalizing the intonation patterns and final syllable tone adjustments for declarative questions.

Declarative statements with a falling intonation are often perceived as questions when the speaker has less knowledge than the addressee on a topic (Xie, 2021). This phenomenon explains why declarative questions are more commonly used in institutional discourse, such as in TV interviews, where the interviewer aims to control the conversation and invites the interviewee to express their opinion. As the interviewer generally has less information on certain topics than the interviewee, declarative statements with a falling intonation are often employed to request confirmation or additional information. However, as shown by the results in Table 1, when declarative questions are used in natural discourse, rising intonation is employed in about half of the circumstances. In natural discourse, both interlocutors are on equal footing, and neither has the responsibility to elicit specific information or control the conversation's direction. Consequently, whether a rising intonation is used as in declarative questions and whether a declarative statement is interpreted as a question can vary from speaker to speaker.

While our study successfully identified declarative questions instances that conform to our definition, we encountered additional complications that challenged our ability to accurately categorize the intonation pattern of some of the examples due to confounding factors such as the Mandarin modal particle 啊. This particle is a toneless syllable that can be attached to the end of a sentence to express the speaker's attitude, but its usage can create ambiguity in determining whether a sentence is declarative, interrogative, exclamative, or imperative (Shao, 2012; Ko, 2022). For example, the highlighted sentence in (11) can be interpreted in different ways by the listener. The pitch contour of this sentence is also shown in (12), where the last toneless syllable 啊 does not deviate from the falling pitch of the penultimate syllable *shài*. Although previous hypotheses suggested that toneless syllables cannot interact with intonational tones, recent perceptual experiments by Zhang (2022) show that pitch range, rather than pitch level, is more significant in signaling the question/statement contrast in utterances ending with neutral tone. Thus, our study's results may benefit from further exploration of the ambiguity surrounding the categorization of declarative questions ending with 啊, and the interaction between toneless syllables and intonational tones, to build a more robust conclusion.

(11)　　A：他们那两边马路有树，就挡太阳。
　　　　　They have trees on both sides of the road, which block the sun.
　　　　B：可以遮阳是吧。
　　　　　It can provide shade, right?
　　　　A：我们那边，光秃秃的一片，全都站在那。
　　　　　On our side, it's completely bare and everyone is just standing there.
　　　　B：直接全部的人都晒啊。
　　　　　So everyone is directly exposed to the sun?
　　　　A：对。
　　　　　Yes.

(12)　　Gloss of the declarative question in (11)
　　　　直接　全部　　的 人　　　都　　　晒　　　　　　　啊。
　　　　zhíjiē quánbù de rén　　 dōu　　shài　　　　　　 a.
　　　　direct all　　DE person QUANT expose to sunlight MOD
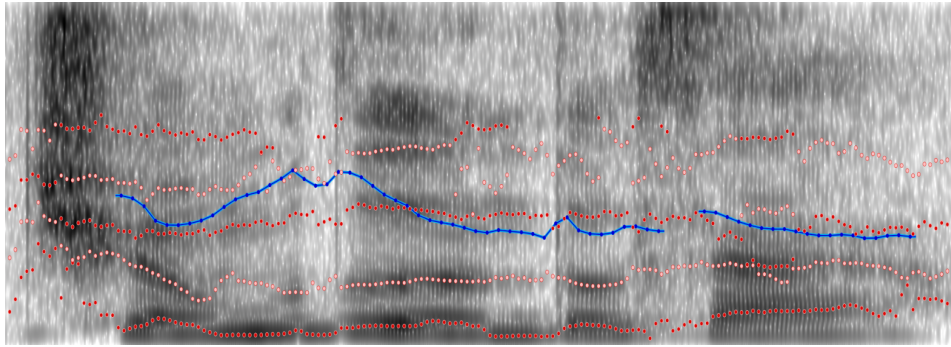
So everyone is directly exposed to the sun?

Figure 2: Pitch contour of 直接全部的人都晒啊 in example (11) shown in blue curve

5.2.   *Results from Experiment*

5.2.1 Sentence-level Intonation

For each pair of declarative questions and their corresponding declarative statement, we generated a bar chart demonstrating the difference in the mean fundamental frequency (measured in Hz) at each syllable between the declarative questions and their corresponding declarative statements. The complete script of the eight sets of dialogs and their corresponding mean F0 differences can be found in the Appendix section, with the target declarative question in each conversation shown in bold text. Our results suggest that the pitch level of declarative questions at each syllable is generally higher compared to statements, with the exception of Tone 3, where the pitch level in the statement could be as low or ever lower than their declarative question counterparts.

A representative bar chart of the mean F0 difference is shown in figure 3. It is worth noting that we did not find a monotonic increase or decrease in the mean F0 differences between questions and statements as the sentences approached the end, as suggested by Yuan's experiment results in Figure 1. Even though the overval pitch level of declarative questions is higher than statements, the F0 difference at different sentence positions varies by the sentence

length and the lexical tone of the syllable. We suspect that this discrepancy might be due to the different elicitation methods used in our study and Yuan's. Specifically, in Yuan's experiment, the questions and declarative sentences were presented in parallel, and participants were requested to read them one after the other. This method likely generated a more uniform contrastive pattern in how the two sentence types were produced. In contrast, our experiment elicited sentences in a context that mimics natural conversational speech, which may have led to greater variability in the way participants produced the sentences.
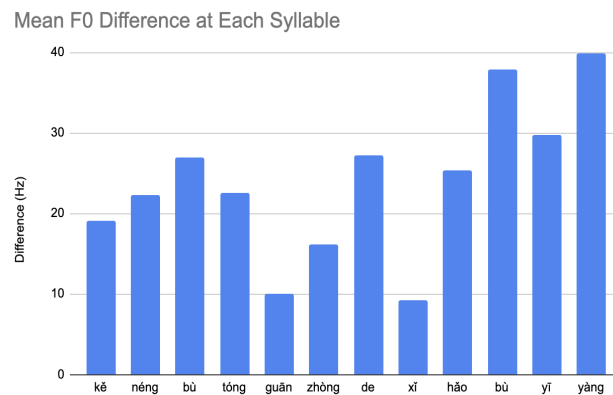
Figure 3: Mean F0 Difference at each syllable for one utterance of the sentence 可能不同观众的喜好不一样 *'Maybe different audiences have different tastes?'*

An exception is that with Tone 3, the mean F0 in the statement could reach a lower level than their declarative question counterparts. The syllable kě in the middle of the sentence in Figure 4 and the sentence-final syllable jǐng in Figure 5 suggest that this exception occurs at different positions of the sentence. This finding is consistent with previous research, which suggests that the F0 value of a Tone 3 syllable in questions could go as low or even lower than statements (Yuan, 2006).
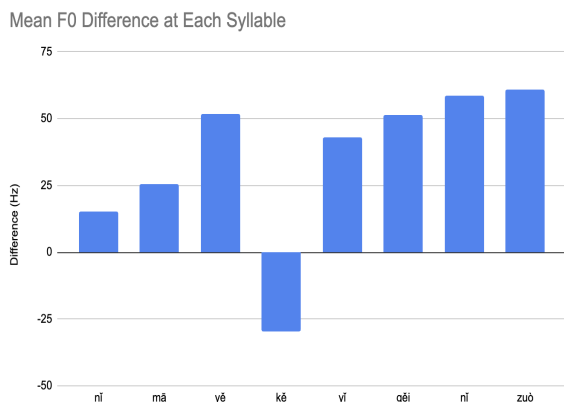
Mean F0 Difference at Each Syllable

Mean F0 Difference at Each Syllable

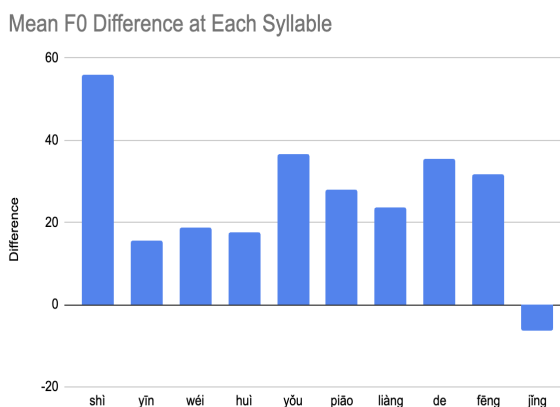Figure 4: Mean F0 Difference at each syllable for one utterance of the sentence 你妈也可以给你做？ *'Your mom could also make it?'*

Figure 5: Mean F0 Difference at each syllable for one utterance of the sentence 是因为会有漂亮的风景？'It is because there will be a pretty view?

5.2.2 Final Syllable

As mentioned in Section 2.3, speakers' identification of the sentence type is mainly influenced by the last one or two syllables in the final prosodic word, and the interaction between tone and intonation is expected to be maximal on the last syllable of the sentence. This section presents the F0 contour of sentence-final syllables in four lexical tones, followed by an analysis of the figures. Specifically, Figures 6–9 show the time-normalized F0 contour of a single token of each speaker producing the syllables *tiān, róu, jǐng,* and *yàng.*
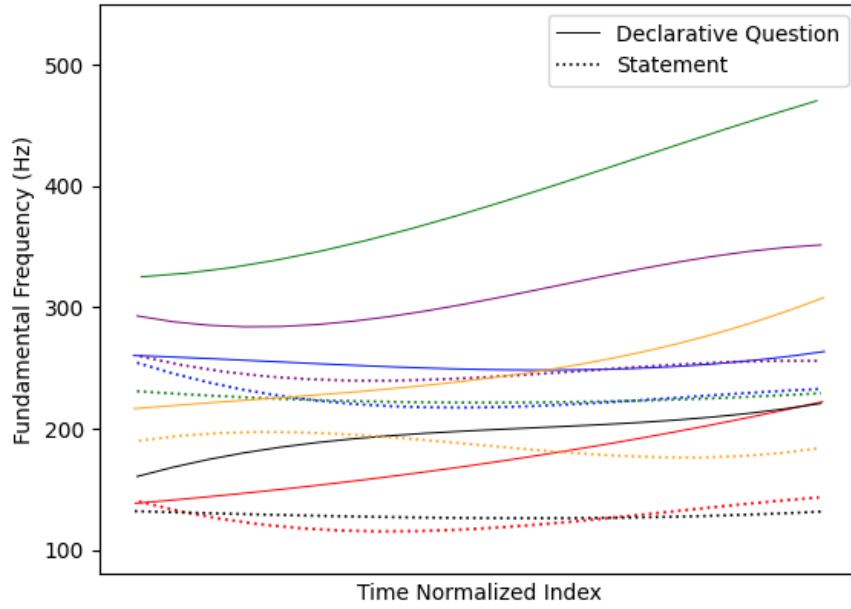
Figure 6: Time-normalized F0 contour of the sentence-final Tone 1 *'tiān'*, each speaker's contour represented by a distinct color, and the color scheme for each speaker is consistent across all figures.
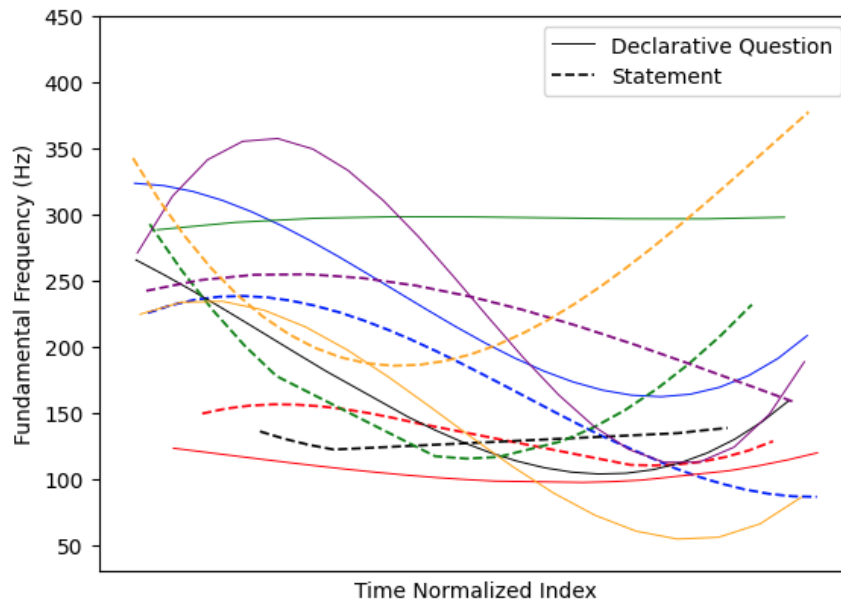

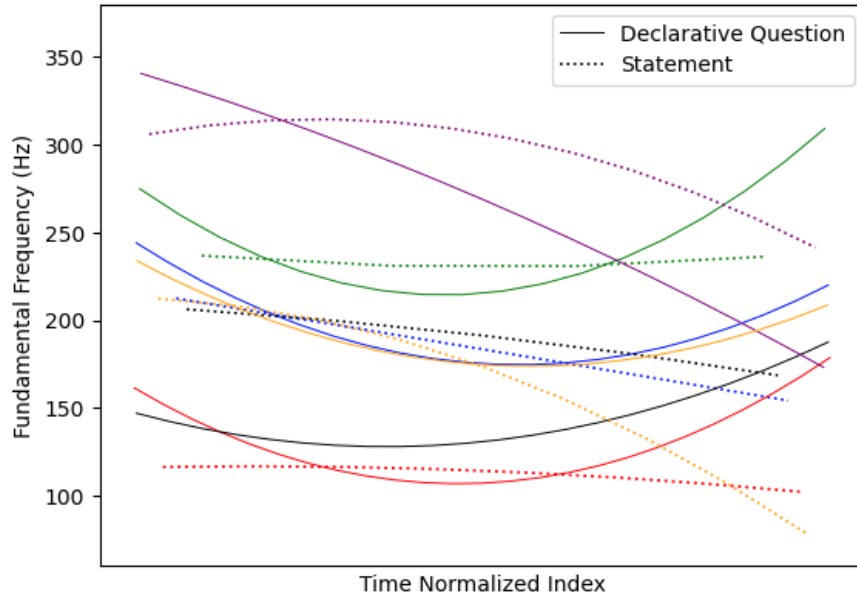Figure 7: Time-normalized F0 contour of the sentence-final Tone 2 *'róu'*

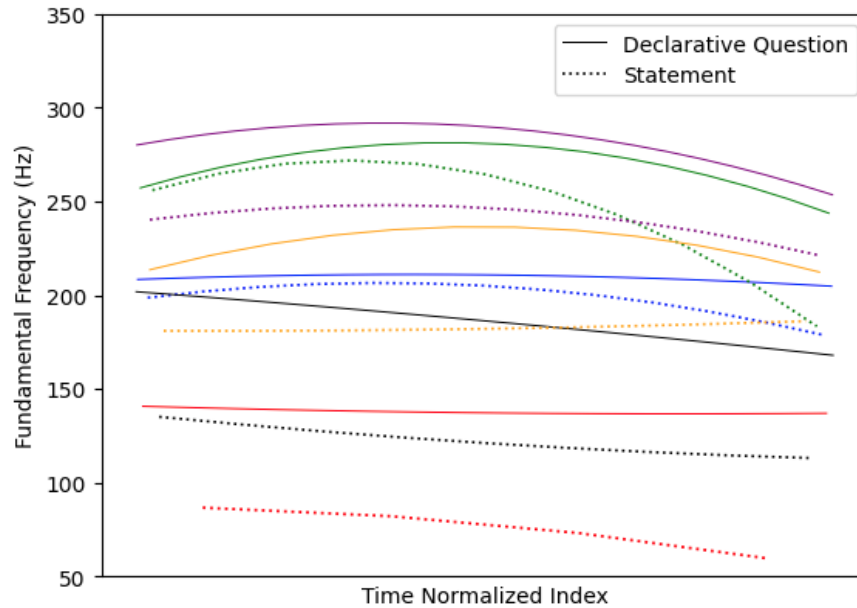Figure 8: Time-normalized F0 contour of sentence-final Tone 3 *'jǐng'*

Figure 9: Time-normalized F0 contour of the sentence-final Tone 4 *'yàng'*

The results in figures 6-9 demonstrate that the declarative question intonation has a significant impact on the tonal realizations of the four lexical tones in a sentence-final position. Tone 1 was consistently realized with a rising slope for all speakers, compared to a flat tone in statements. Also, Tone 1 is realized with a higher starting F0 in declarative questions compared

to statements. For Tone 2, there are no uniform intonation patterns found across speakers in our data. This suggests dissimilar results to Zeng (2004)'s study, where the pitch contour of Tone 2 is descending-ascending in both declarative questions and statements, and the overall register is higher. The third-degree polynomial regression of speakers F0 values show that not all speakers produced Tone 2 with a clear turning point, and for the speakers who do, there is no general pattern in terms of the effect of sentence type on the turning point in the normalized time frame. For example, for the speaker indicated by the red line, the turning point occurs earlier in declarative questions, whereas for the speaker in the yellow line, the turning point occurs earlier in statements. For Tone 3, a clear turning point was observed in the pitch contour for most speakers, with a falling and rising pitch contour in declarative questions compared to a flat or falling contour in statements. In Tone 4, the falling slope of pitch contours in statements was less accentuated or replaced by a shallowly ascending slope.

The analysis conducted suggests that tonal realizations vary across sentence types and speakers. As shown by the comparison of Tone 1, Tone 3, and Tone 4, rising intonation at the end of a declarative question is a common practice employed by most speakers, which affects the realization of the lexical tone in the sentence-final position. However, there seems to be no clear pattern in the pitch contour modification of Tone 2, indicating that the use of rising intonation in declarative questions may be dependent on the lexical tone of the sentence-final syllable. Further studies could be conducted to investigate this by controlling for confounding variables such as sentence focus and the lexical tone of the penultimate syllable. Such studies could help shed more light on the relationship between intonation and lexical tone in declarative questions.

6.   Discussion and Conclusion

This thesis explores the intonation pattern of declarative questions in Mandarin conversational speech. Initially, we investigate whether the use of rising intonation in declarative questions is dependent on the type of declarative question, such as assertive or inquisitive. Our corpus analysis reveals that the proportion of rising intonation is similar for both types, at around half of the instances examined. Given the lack of significant differences found in the first part of the study and the small scale of the research, we treat both types of declarative questions uniformly in the experiment design and data analysis in the second part of the study. The experiment data suggests that declarative questions have an overall higher pitch contour than their statement counterparts, and most speakers use rising intonation at the end of declarative sentences when they are aware of the interrogative function. Additionally, the use of rising intonation modifies the tonal contour of sentence-syllables in various ways based on the lexical tone.

Another motivation for conducting this study is to explore the connection between the intonation of declarative questions and their pragmatic functions in different contexts. Using the two-part analysis of corpus data and experimental data, we revealed a difference in the use of rising intonation to facilitate the perception and production of declarative questions. In the context of our study, whether a form has fulfilled its questioning function is assessed based on its response. For example, if the respondent gives a positive or negative answer, or indicates their inability to answer, it proves that the previous speech act served as a questioning function (Gao, 2005). The natural speech data in the corpus shows only around half of the declarative questions fulfilled the interrogative function and were correctly perceived by the addressee without using a rising intonation. In contrast, when speakers were provided a context to intentionally use declarative questions to perform the interrogative function, the target questions were produced

with a rising intonation by nearly all of the participants. This contrast in the use of rising intonation suggests that speakers associate declarative questions with a rising intonation in speech production, but the use of rising intonation might not be the single cue for a declarative question to be interpreted as a question in a conversational context. As mentioned in the literature review section, the set of common knowledge shared by the interlocutors, the expectation of the roles of the speakers, like interviewer and interviewee, in Xie (2021)'s analysis, are both factors that could influence the production of rising intonation in declarative questions. It is also important to note that this investigation relied on the personal judgment of the author on whether rising intonation is present in a declarative question in the corpus data. It would be helpful to recruit multiple native speakers of Mandarin to make a collective decision on whether there is a rising intonation in the sentence.

Our study also attempted to explore the classification of declarative questions and its relation to intonation patterns, which the previous literature on Mandarin declarative questions has not extensively explored. To achieve this, we employed Jeong (2021)'s categorization schema to identify instances of inquisitive and assertive declarative questions and found that rising intonation was comparably used in both types. As Jeong's study suggests, both acquisitive declarative questions and inquisitive declarative questions in English exhibit sentence-final rise, but inquisitive declarative questions have a lower tone at the starting point (L* H-H%) than assertive declarative questions (H* H-H%). Building on this insight, a potential explanation for our study results is that the presence of rising intonation was not sufficient to distinguish between the two types of declarative questions in Mandarin. Instead, there might be other intonational differences, such as the duration or slope in the tonal contour of the sentence-final syllables. Nevertheless, the small sample size and focus on rising intonation limit our study's scope, but our study opens up opportunities for future research to explore other intonational cues

to distinguish these two types of declarative questions more accurately. This study contributes to the understanding of the relationship between intonation patterns and pragmatic functions of declarative questions in Mandarin conversational speech, and provides a foundation for further exploration of the intricate interplay between intonation and pragmatics in natural speech. In this way, we hope that our study can inspire future research and lead to a deeper understanding of the role of intonation in Mandarin declarative questions.

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Appendix

A: 张三邀请我们下周去参加他的生日派对。
A: Zhangsan invites us to his birthday next week.
B: 他的生日在下个星期天？
B: His birthday is next Sunday?
A: 对。
A: Yes.

Mean F0 Difference at Each Syllable
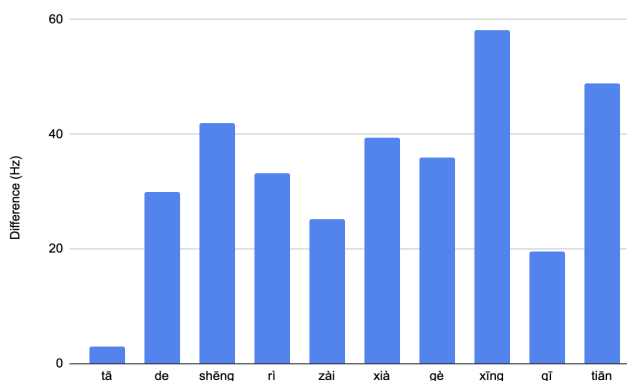
A: 你们军训的时候教官好吗？
A: How is your officer during military training?
B: 挺不错的。
B: Pretty nice.
A: 你们班同学是怎么评价他的？
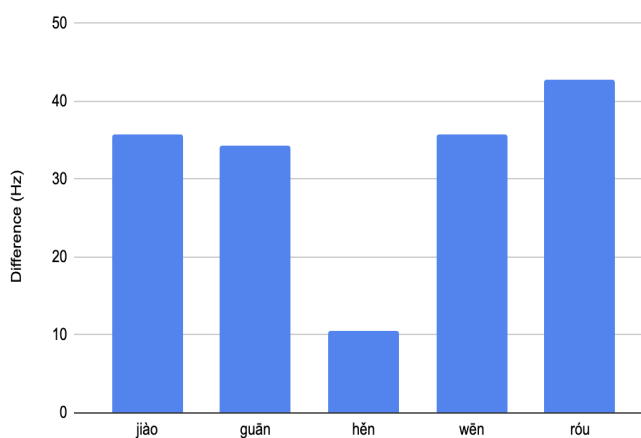A: What does your classmates think of him?
B: 挺温柔的。
B: Very gentle.
A: 教官很温柔？这是我第一次听这个词啊。
A: The officer is gentle? That's the first time I heard this word (describing an officer).
B: 对，我们的教官比较好。
B: Yeah, our officer is very nice.

Mean F0 Difference at Each Syllable

A: 我们学校食堂的番茄鱼很好吃。
A: The tomato fish stew at our cafeteria is delicious.
B: 我去尝过，是还不错，以前我妈在家也总是做。
B: I've tried it before. It's pretty good. My mom always makes it at home.
A: 你妈也可以给你做？

Mean F0 Difference at Each Syllable
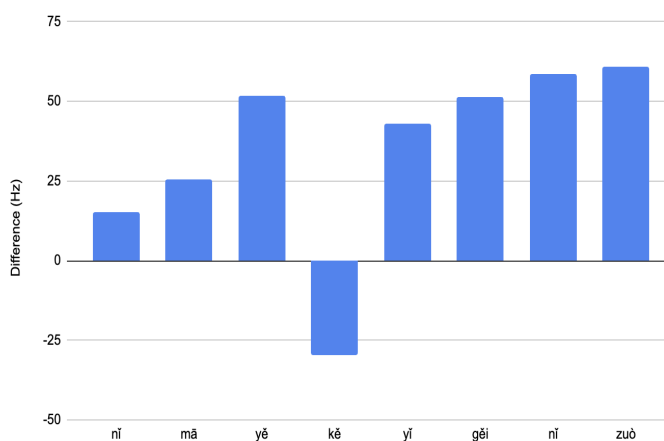
A: Your mom could also make it?

B: 嗯，我妈做饭可好吃了，有空去我们家做客！

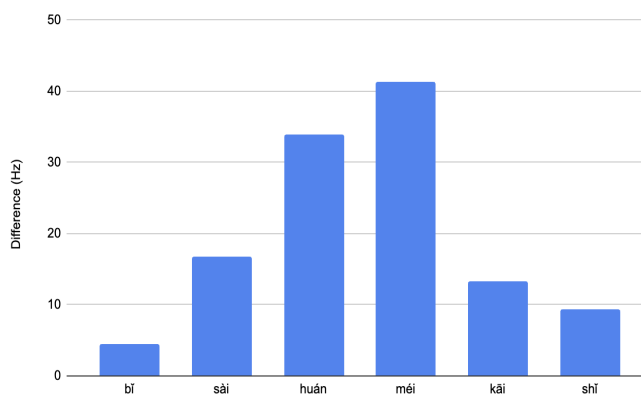B: Yeah. My mom is a great cook. You should come to have dinner sometime.

A: 比赛还没开始？

A: The game hasn't started?

B: 还没呢。

B: Not yet.

Mean F0 Difference at Each Syllable

A: 你爸爸妈妈把房子卖掉了供你学音乐，那他们住哪？

A: Your mom and dad sold their house to support you to study music. Where are they living now?

B: 住在我们以前的老房子里，那个地方特别小。

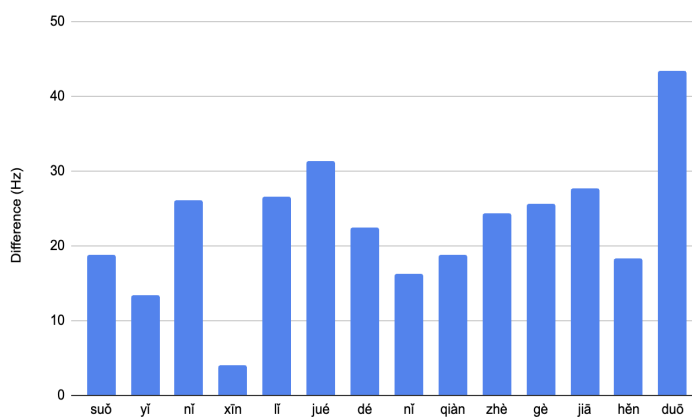B: In an old house we used to live. That place is very small.

A: 所以你心里觉得你欠这个家很多？

A: So you think you own this family a lot?

B: 对，我觉得我怎么还都还不清。

B: Yes, I don't think I can ever pay them back.

Mean F0 Difference at Every Syllable

A: 我最近在一个项目上一直拖延。

A: I have been procrastinating on a project.

B: 你是因为找不到资源所以拖延？

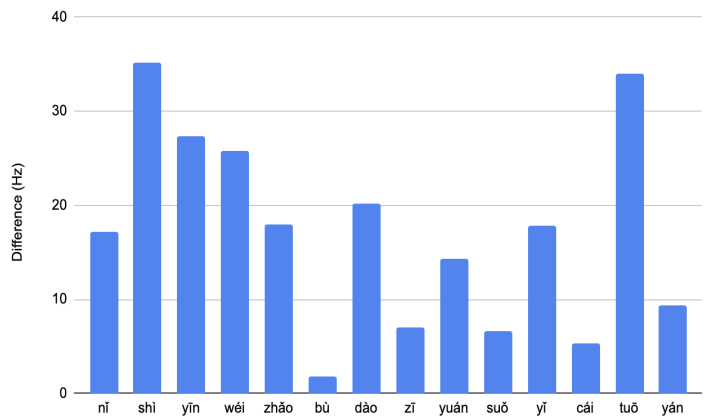B: You are procrastinating because you can't find enough resources?

A: 也不是。我收集到的资料太多了，我还没来得及整理。

A: Not really. I collected too much materials, but I haven't found the time to organize them yet.

B: 那你慢慢来。

B: Take your time.

Mean F0 Difference at Each Syllable

A: 天气预报说后面几天都会出太阳。

A: The weather forecast says it will be sunny in the following days.

B: 真的吗？我很喜欢阳光明媚的天气。

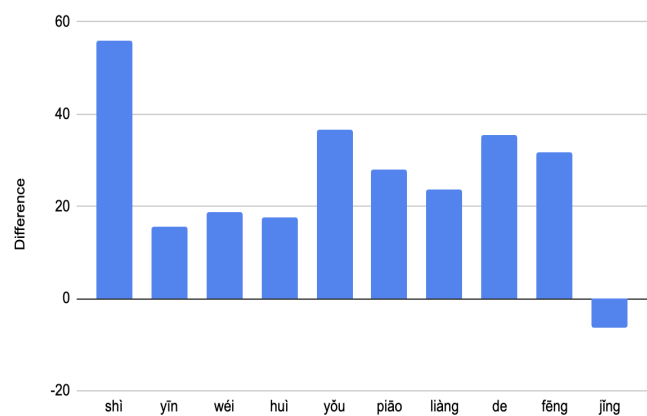B: Really? I like sunny days so much.

A: 是因为会有漂亮的风景？

A: It is because there will be a pretty view?

B: 是啊，在阳光的照射下所有事物都会显得很美好。

B: Yeah, everything appears beautiful under the sunlight.

Mean F0 Difference at Each Syllable

A: 那部电影的评价特别两极分化。

A: The opinion of that movie is very polarized.

B: 可能不同观众的喜好不一样？

B: Maybe different audiences have different tastes?

A: 确实，喜欢看科幻片的好像更喜欢这部电影。

A: Indeed. People who watch science fiction movies seem to like it more.

Mean F0 Difference at Each Syllable