



Production and Perception of Incredulity in Yes-no Question Intonation in Taiwan Mandarin

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Abstract

This study intends to investigate the effect of incredulity on yes-no question intonation in Taiwan Mandarin. Mandarin yes-no question is formed by adding the sentence-final particle *-ma*, and it usually sounds incredulous when *-ma* is absent. To examine how incredulity interacts with *-ma*, three question conditions were designed, including neutral question with *-ma*, incredulous question with *-ma*, and incredulous question without *-ma*. For the production experiment, an elicitation task was conducted, and pitch realizations were measured. In the perception experiment, listeners performed a forced-choice judgment task on incredulity. Results showed that incredulity was closely associated with pitch height, and there exhibited a gradient relationship. In addition, the question particle *-ma* also exerted an effect on the production and perception of incredulity.

Index Terms: incredulous question, perceive incredulity, question particle, Taiwan Mandarin

1. Introduction

Languages extensively exploit prosodic cues to convey distinct pragmatic meanings. Question intonation, for example, is commonly associated with higher pitch register [1]. When questions are uttered with incredulity, or surprise, an even larger degree of pitch raising and expansion is usually observed, indicating greater speaker involvement [2]. The intimate relationship between pitch adjustment and interrogative/incredulity is similarly reflected in perception. In many languages, an increase in pitch height and magnitude results in percepts of interrogatives and incredulity [3][4][5].

Irrespective of the general effect of pitch raising and expansion, the specific patterning of cue weighting and interaction is however language-dependent. For instance, while rise-fall intonation is characteristic of both neutral question and echo question in Russian, it is mainly reserved for exclamation in Japanese. When perceiving a rise-fall intonation, Japanese listeners are more likely to associate it with exclamation than Russian listeners [6]. In the same vein, Crespo Sendra et al. [7] studied how incredulity is perceived in Catalan and Dutch. Given that incredulity involves tonal change in Dutch, but not in Catalan, Catalan listeners rely more on visual cues, i.e., facial expression, than Dutch listeners when determining whether an utterance is incredulous or not.

In Mandarin, to form yes-no questions, one usually adds the sentence final particle *-ma* to statements, as shown in (1).

- (1) Statement: *Ta¹ shi⁴ yi¹sheng¹*. ‘He is a doctor.’
Yes-no question: *Ta¹ shi⁴ yi¹sheng¹ ma⁰?* ‘Is he a doctor?’

Consistent with other languages, yes-no questions in Mandarin are also higher in pitch register than corresponding statements [8]. However, there exist discrepancies with respect to contour realizations of *-ma* questions. Chiang [9] found that similar to statements, *-ma* questions are featured with a descending pitch trend and end low. In contrast, Sung and Chiang [10] suggested that the final particle *-ma* carries a high tone, causing a rise toward the end of the question. Chang’s [11] results are more in line with Chiang [9], as she found the pitch contour of *-ma* questions to be “slightly descending.”

It is also possible to construct Mandarin yes-no questions without adding the final particle *-ma*, leaving the syntactic form of statements unaltered, as in (2).

- (2) Question without *-ma*: *Ta¹ shi⁴ yi¹sheng¹?* ‘Is he a doctor?’

When *-ma* is absent, questions usually sound incredulous. Lee [12] revealed that incredulous questions without *-ma* are characterized by larger pitch expansion, compared to neutral questions with *-ma*. Nonetheless, Chang [11] discovered individual differences in realizing incredulous questions. Only one speaker in her study produced questions without *-ma* using higher pitch register than questions with *-ma*. The other two speakers actually exhibited the opposite tendency; i.e., questions with *-ma* showed higher pitch globally than those without *-ma*.

On the perception side, Chang [11] reported a robust correlation between pitch height and interrogatives/incredulity. Higher pitch tends to induce more responses of question and incredulity. Interestingly, Chang distinguished between “incredulous questions” and “incredulous statements,” and she observed that when *-ma* is cut off from the original signal, those perceived as incredulous questions are higher in pitch than those perceived as incredulous statements. Furthermore, the particle *-ma* itself also determines whether incredulity is perceived. When *-ma* is present, listeners perceive questions to be incredulous if *-ma* is realized with a high tone. Contrarily, perception is biased toward neutral questions if *-ma* carries a mid or mid-low tone. Taken together, these studies have illustrated the complicated interaction between syntax, pragmatics, and prosody in producing and perceiving question intonation in Mandarin. While higher pitch register undoubtedly contributes to the identification of interrogatives and incredulity, further investigation is still required in order to map out the detailed production-perception relationship between question intonation and *-ma*.

2. Aims of the study

There are three specific aims in this study. The first is to examine pitch realizations of question intonation in Taiwan

Mandarin. In addition to neutral questions with *-ma* and incredulous questions without *-ma*, the present study also looked into incredulous questions with *-ma*. One speculates that the inconsistencies among previous studies might have been due to the fact that varying degrees of incredulity are expressed in questions with and without *-ma*. Thus, the opposing pitch trend of *-ma* questions in Chiang [9] and Sung and Chiang [10] might possibly be due to the fact that Chiang's speakers did not intend to sound incredulous while Sung and Chiang's speakers were attaching incredulity to *-ma* questions. In addition, individual differences as reported by Chang [11] could also be because some speakers expressed questions without *-ma* with more incredulity than questions with *-ma*, whereas others did the opposite. It is hoped that in this study, by giving clear instructions of being incredulous or not to speakers, the intonation of questions with *-ma* and that of incredulity could be better understood.

The second research goal concerns the perception of incredulity in Mandarin question intonation. Although Chang [11] has shown that high rising pitch is strongly correlated with incredulity, the relationship between production and perception was however not explicitly explored in her study. It thus remains unclear whether the perception of incredulity is categorical or gradient. If the contrast between neutral and incredulous questions is gradient, as in Catalan [5], one should be able to observe positive correlations between pitch height and the degree of incredulity, regardless of question types.

Lastly, this study intends to investigate the role that *-ma* plays in affecting the production and perception of incredulous intonation. As almost all previous studies only compared neutral questions with *-ma* with incredulous questions without *-ma*, the effects of *-ma* and incredulity have been confounded, and it is still unknown whether and how *-ma* might influence the production and perception of incredulity. Since both *-ma* and incredulity share the same phenomenon of pitch raising [11], if the two effects are accumulative, one would expect that the presence of *-ma* will result in a further increase of pitch height, above incredulous questions without *-ma*. As for perception, incredulous questions with *-ma* might then require an even higher pitch register to be perceived as incredulous.

3. Method

3.1. Production experiment

3.1.1. Participants

Ten female native speakers of Taiwan Mandarin were recruited. They were aged from 18 to 30 at the time of recording.

3.1.2. Stimuli and procedure

Stimuli were four two-syllable proper names with identical adjacent tones – *Ou¹la¹*, *Liu²min²*, *Li³mei³*, and *Ye⁴na⁴*. All syllables were made up of sonorants for the purpose of complete pitch extraction. Each name was assigned to a distinct cartoon character. These four names were inserted into a carrier sentence, *Ta¹ shi⁴ _____*. 'S/he is _____.' There were three question conditions, including neutral questions with *-ma* (NQm), incredulous questions with *-ma* (IQm), and incredulous questions without *-ma* (IQ). Target questions and cartoon characters were presented together to the speakers. Appropriate pragmatic contexts were given orally by the experimenter to facilitate elicitation. Incredulity was evoked by mismatching

names and characters. The three question conditions were repeated once. There were in total 240 tokens of production (3 question types × 4 proper names × 10 speakers × 2 repetitions). For detailed procedure of the elicitation, please refer to Chuang, Huang, and Fon [13].

3.1.3. Data analyses

The pitch contour of the final syllable (excluding *-ma*) in each question was extracted. F₀ of each syllable's high tonal target was measured. For high-level Tone 1 (T1), it was the maximum F₀ of the entire syllable. For rising Tone 2 (T2), the maximum F₀ of the final rise was measured. For dipping Tone 3 (T3), it was the initial high of the syllable, given that the final rise is optional in Taiwan Mandarin. For falling Tone 4 (T4), the F₀ value of the initial high was measured.

In addition to target syllables, the maximum F₀ of *-ma* in IQm and NQm was measured as well. Considering pitch differences inherent to each speaker, we also measured the initial syllable *ta¹'s/he'* as a reference.

3.2. Perception experiment

The goal of the perception experiment is to determine the degree of incredulity of each question produced by our speakers.

3.2.1. Participants

Listeners were ten native Taiwan Mandarin speakers (three females and seven males), aged from 18 to 30. None of them had participated in the production experiment.

3.2.2. Stimuli and procedure

All the questions elicited in the production experiment were divided into two lists, each of which contained productions of all three question conditions and of all speakers. Five listeners were assigned to each list, and they were instructed to perform a forced-choice task with three options: neutral, incredulous, and uncertain. The inter-stimulus interval was four seconds, with no repetition. The whole experiment took about fifteen minutes.

3.2.3. Data analyses

Listeners' responses were transformed into incredulity scores. If one listener considered the question to be incredulous, then it received one point. The response of 'neutral' and 'uncertain' equaled to zero and 0.5, respectively. The scores were summed up for each token. Since each question was judged by five listeners, the maximum score was five and the minimum was zero. It was later noted that one of the speakers spoke with a strong Taiwanese Mandarin accent. To avoid unwanted effects, her data were excluded from current analyses.

4. Results

4.1. Pitch height measurement

Figure 1 presents the F₀ values of the target syllable and the reference syllable *ta¹*. Incredulous questions (IQ and IQm) involved a global pitch raising, since both the reference and target syllables were higher in pitch than those of neutral questions (NQm). IQ and IQm overlapped to a large extent but the former was slightly higher. A two-way repeated measure of Question (IQ/IQm/NQm) and Tone (T1/T2/T3/T4) was conducted on the F₀ values of the target syllables. The lexical

tone of the target syllable was included to examine whether it would interact with different question types. Results showed that both the main effects of Question and Tone reached significance [Question: $F(2, 34)=35.92, p<.001$; Tone: $F(3, 51)=16.07, p<.001$]. Overall, IQ had the highest pitch ($\bar{X}=357.76$), followed by IQm ($\bar{X}=323.87$), and NQm were realized with the lowest pitch register ($\bar{X}=248.92$). Post hoc tests revealed that all pairwise comparisons were significant ($p<.001$).

The F_0 values of *-ma* with reference to the *ta*¹ syllable are shown in Figure 2. Similar to target syllables, *-ma* in IQm was realized with higher pitch than that in NQm. A Question (IQm/NQm) \times Preceding tone (T1/T2/T3/T4) two-way repeated measure on the F_0 of *-ma* was conducted. Again, both main effects were significant [Question: $F(1, 17)=30.33, p<.001$; Tone: $F(3, 51)=5.15, p<.005$], but not the interaction effect. The mean F_0 value of *-ma* in IQm was 297.28 Hz, whereas that of *-ma* in NQm was 233.38 Hz. The results thus illustrated that in the incredulous condition, the particle *-ma* was raised in pitch along with other syllables in the sentence.

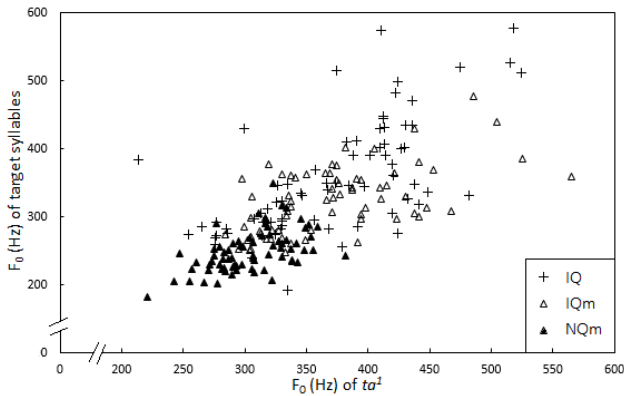


Figure 1: F_0 values (Hz) of the reference syllable *ta*¹ and the target syllable.

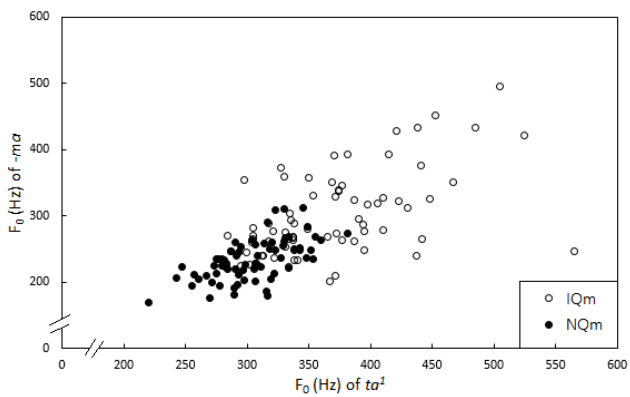


Figure 2: F_0 values (Hz) of the reference syllable *ta*¹ and the particle *-ma*.

4.2. Pitch height and the degree of incredulity

Figure 3 shows the scatter plots of target syllables' F_0 values and incredulity scores. The perceived degree of incredulity was positively correlated with pitch height for all three question types [IQ: $r=.46, p<.001$; IQm: $r=.55, p<.001$; NQm: $r=.57, p<.001$].

The perceived degree of incredulity was also compared across question types. Since IQ had the highest pitch height, followed by IQm and then NQm, one speculated that incredulity scores might have also differed in the same fashion. Statistical analyses confirmed this hypothesis. One-way repeated measure was conducted on incredulity scores, and the effect of question type was significant [$F(2, 142)=135.02, p<.001$]. The perceived incredulity of IQ ($\bar{X}=4.18, SD=1.53$) was significantly higher than that of IQm ($\bar{X}=3.38, SD=1.86$), which was in turn higher than that of NQm ($\bar{X}=0.88, SD=1.05$) ($p<.001$).

Given that the pitch height order was $IQ > IQm > NQm$, which leads to the same order of incredulity scores, one wonders whether pitch height alone could determine the perceived degree of incredulity. More specifically, will question type still affect incredulity scores, after partialing out the effect of pitch height? To examine this aspect, hierarchical regression analyses were conducted on incredulity scores. Independent variables were pitch height and question type. Since question type is a categorical variable, IQm was set as reference because it enables us to compare both the effect of incredulity (IQm vs. NQm) and the effect of *-ma* (IQm vs. IQ). As displayed in Table 1, the addition of question type in step 2 significantly increased the accountability of the model. In particular, when switched from IQm to NQm, the degree of incredulity significantly decreased. When switched from IQm to IQ, there exhibited a tendency of increasing incredulity degree, though it was only marginally significant. Taken together, the results illustrated that in addition to pitch height, the perceived degree of incredulity would also be affected by question types.

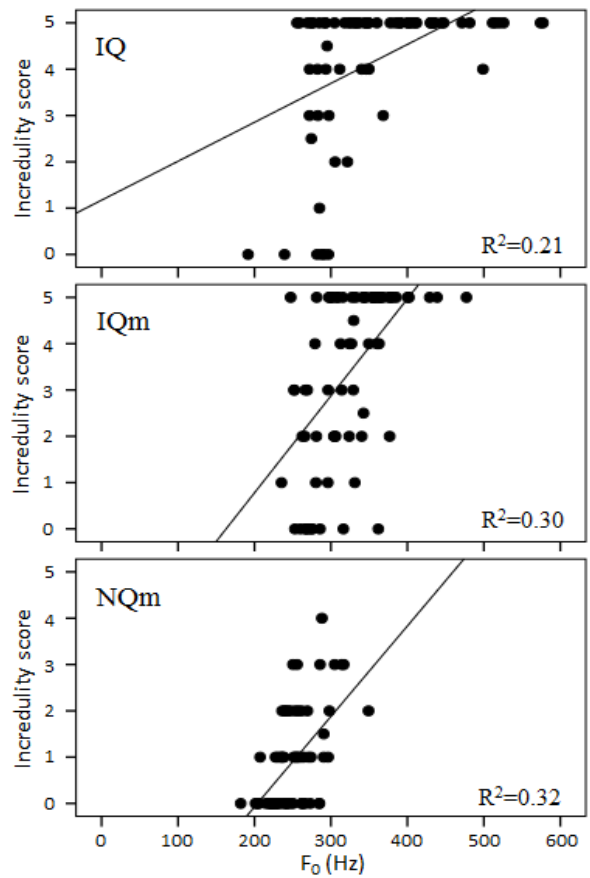


Figure 3: F_0 values (Hz) of the target syllable and the perceived degree of incredulity.

Table 1. The hierarchical regression analysis of the perceived degree of incredulity.

| Variable | β | t | R | ΔR^2 | ΔF |
|--------------|---------|-------------------|-----|--------------|------------|
| Step 1 | | | | | |
| Pitch height | .69 | 14.07** | .69 | .48 | 197.94** |
| Step 2 | | | | | |
| Pitch height | .44 | 7.90** | .76 | .11 | 27.10** |
| IQ | .09 | 1.69 ⁺ | | | |
| NQm | -.36 | -6.23** | | | |

Note: ** $p < .01$, * $p < .05$, ⁺ $p < .1$.

5. Discussion

This study investigated the production and perception of incredulous questions in Taiwan Mandarin. Specifically, pitch height realizations of three question types were examined, including neutral questions with the final particle *-ma*, and incredulous questions with and without *-ma*. F_0 measurements revealed that no matter whether *-ma* is present, incredulous questions were always realized higher in pitch than neutral *-ma* questions. This pitch raising effect is most likely to be triggered by high boundary tone (H%), as suggested by previous researchers [10][11][12]. In addition, the pitch realizations of *-ma* (Figure 2) further showed that although *-ma* is traditionally considered to carry neutral tone in Mandarin, whose tonal realization is largely dependent on the preceding syllable [14], similar to syllables with lexical tones, it is affected by incredulity in the same fashion. The current results therefore accounted for the discrepancies with regard to question intonation in Mandarin reported in previous studies, as some showed that *-ma* questions are characterized with descending pitch contours [9][11], while others found rising contours [10]. With the design in this study, it becomes clear that instead of having two opposing question contours, the contradictory findings of previous studies might have been due to speakers' inconsistent intention of expressing incredulity in their production of questions.

Interestingly, although pitch raising was similarly observed in both IQ and IQm, their magnitude however differed. It was found that greater degree of pitch raising was associated with IQ than IQm, indicating an interaction between incredulity and the question particle *-ma*. It appeared that *-ma* would attenuate the magnitude of pitch raising for incredulity. One possible explanation is that the high boundary tone of incredulous intonation has acted on different syllables in IQ and IQm. In IQ, H% had a direct effect on the target syllable, which is in the sentence-final position, whereas in IQm, the target syllable is in the penultimate position. The effect of H% might thus have been lessened in IQm. Another possibility is due to the infrequent combination of the question particle *-ma* and incredulity. Since *-ma*-marked questions in Mandarin are generally interpreted as neutral questions without incredulity, when *-ma* is present, it might have caused some difficulty for speakers to apply the same pitch raising effect as that in questions without *-ma*, whose unmarked interpretation is incredulous. In other words, although *-ma* causes pitch raising [8] and so does incredulity, the two effects cannot be accumulative, contradictory to our earlier hypothesis. Whether such an attenuating effect is specific to *-ma* questions, or it is general to other question types will still require further studies.

In this study, the production-perception relationship with respect to incredulity intonation was also investigated. A judgment test was conducted to examine whether pitch height and the perceived degree of incredulity exhibit a gradient

correspondence. The results largely confirmed this hypothesis, since positive correlations were obtained for all three question conditions. The gradient pattern resembles that found in Catalan [5] to a large extent. Comparisons made across question types again proved the intimate relationship between pitch height and incredulity perception. As IQ was generally higher in pitch than IQm, whose pitch realization was higher than NQm, the perceived degree of incredulity also followed the same order: IQ sounded the most incredulous, IQm was the second, and finally NQm sounded the least incredulous.

Despite the important role that pitch height plays in affecting incredulity perception, it is however not the sole factor. Regression analyses demonstrated that with the effect of pitch height being partialled out, question type still had predicting power on incredulity scores. That is, disregarding the influence of pitch height, we still observed that incredulity scores decreased in NQm and increased in IQ, and the former effect was more robust than the latter. For the IQm-NQm comparison, given that they shared the same form, listeners must have considered other prosodic parameters in addition to pitch height when deciding whether a question was incredulous or not. One of these parameters might be duration, though cross-linguistically it is usually a more minor cue than pitch [5][6].

As for the IQm-IQ comparison, the difference lies in whether the particle *-ma* is present. Current analyses indicated that given the same pitch height, the presence of *-ma* would lead to a decrease of perceived incredulity. It was suspected that the perceptual results could have again resulted from the incompatibility between *-ma* and incredulity. As Mandarin speakers are not used to *-ma* questions with incredulity, they were likely to be more reserved when deciding whether the *-ma* question was incredulous or not. The overall incredulity scores would therefore be lower. Alternatively, the influence of *-ma* on incredulity perception could also be accounted for from another perspective. In Chang's [11] study, tokens that were judged as "incredulous question" were realized with higher pitch than those judged as "incredulous statement." Although it is not clear how listeners in her study were instructed to distinguish between incredulous questions and statements, following her results one would expect higher pitch realizations for a question to sound incredulous. Since the presence of *-ma* is an unambiguous index for questions, listeners probably have raised their criteria for incredulity, and IQm was thus perceived to be less incredulous than IQ. It is worth noting, however, that if this is the case, then there exists a mismatch between production and perception. On one hand, speakers could not produce IQm with sufficient pitch height, as shown in our production data; on the other hand, listeners would expect IQm to be higher in pitch. More studies should be devoted to unraveling the production-perception relationship.

To conclude, this study has demonstrated that incredulity has a pitch raising effect on the intonation of yes-no questions in Mandarin, resolving the conflicting findings reported in previous studies. In addition, it was found that pitch height and incredulity scores are positively correlated and exhibit a gradient relationship, and higher pitch induces a more incredulous percept. Finally, the question particle *-ma*, when present, attenuates the pitch raising effect of incredulity and also diminishes the perceived degree of incredulity. It was suspected that because *-ma* questions are by default not incredulous, the combination has yielded to attenuating effects in both production and perception. Future studies should focus on other question forms or particles to better our understanding of incredulous intonation.

6. References

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