



Gender- and register-biased patterns in f0 use: How does prosody contribute to (in)formality in Japanese?

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Abstract

The phonological organization of a language restricts the way in which pitch range can be realized lexically and/or intonationally. Previous studies on tonal languages have shown that a phonological grammar demanding a particular tonal classification affects the variability in pitch range: in tonal languages, smaller variations are observed compared to non-tonal languages.

Research on Japanese, a language with lexical pitch accent, suggests that although the range of allowed f0 variations is smaller than in non-tonal languages, speakers make use of pitch range in specific pragmatic situations. Gender and formality were found to be good predictors of pitch range variations. Specifically, contrary to the intuitive judgment about gender differences in pitch range, in Japanese male speakers have a wider pitch range than female speakers.

Based on the analysis of the Corpus of Spontaneous Japanese, this study provides further insights on the nature of this gender difference in pitch range. Furthermore, we explore how Japanese speakers make use of f0 to express formality. Our results suggest a tendency in male speakers to use higher f0 in informal contexts. Additionally, we found that contrary to the frequency code theory, it is informal speech that is associated with a higher f0.

Index Terms: Japanese, sociophonetics, f0 range, corpus study, gender, register, formality

1. Introduction

Intonational patterns in a language are restricted by its phonological organization. Namely, the way in which pitch patterns are realized both lexically and in the intonation depends on language-specific properties [1, 2, 3] and thus, the inventory of intonational tones that can be used by speakers in specific situations is determined accordingly.

Some illustrations of this principle can be found in the body of research on pitch range, for example in Infant Directed Speech. Previous studies suggest that the variations in intonation in tonal languages (e.g. Chinese, Thai) are less important than those observed in languages that do not have a tonal contrast (e.g. English) [4]. When making a comparison of pitch range variations between Japanese and Western languages, the former exhibits less variations [5].

Japanese is a language with lexical pitch accent (moras can bear either a high (H) or low (L) pitch) but no intonational accent [6]. It has however been reported to make use of phrasing to mark focus, for example. The contrast based on pitch accent

in Japanese plays a crucial role, as indicated by the variety of minimal pairs that can be found in the language. This is exemplified in (1-3).

| | | | |
|----------------|-----|------------------|-----|
| <i>kaki-ga</i> | LHH | ‘persimmon- NOM’ | (1) |
| <i>kaki-ga</i> | HLL | ‘oyster- NOM’ | (2) |
| <i>kaki-ga</i> | LHL | ‘fence- NOM’ | (3) |

While in English accent placement is determined based on an interplay of various linguistic and extra-linguistic factors, in Japanese pitch accent is a property of a given word. A logical consequence of this property of the language is a restriction of the allowed variations in pitch [7], as they might interfere with the meaning, causing a neutralization of contrastive items.

Previous studies from various fields point out some more evidence for the nature of Japanese with regard to intonation such as the use of particles and the interaction of culturally specified rules. In psycho-linguistics for example, there is a body of research on the perceptual cues for emotions in speech, which sheds light on the influence of social rules on Japanese speech. It appears that changes in f0 for Japanese speakers are attenuated, and this is possibly due to the social rules governing the display of social affects in Japanese (e.g. [8]): that is, self-restraint is viewed as a quality, and not displaying emotions is a more socially accepted behavior in Japanese culture. On the linguistics side, it was noted by [5] that, while in English questions are marked with intonational cues (e.g. pitch raise sentence-finally), Japanese speakers may avoid this by making use of the interrogative particle *-ka*. In this way, Japanese listeners are actually able to distinguish affirmative from interrogative sentences based on syntactic markers only (i.e. questions are signaled by *-ka*), and in this case the recourse to intonational cues is not needed. Note, however, that in informal speech the interrogative particle can be omitted (cf. Section 4 of this paper).

On the other hand, previous studies focusing on intonation in Japanese point out that in specific pragmatic situations speakers can in fact make use of significant pitch range variations (expansion or reduction). In infant-directed speech, for example, adult speakers exhibit a wider pitch range in their interactions with infants than with other adults [4, 9]. [10] and [11] also shed light on variations in f0 between “normal” and “maid” voices in Japanese, and that even further modifications of pitch range can occur within the “maid” voice category: based on the character they play, maids may change their high/low tonal targets, which results in an expansion/reduction of their pitch range.

The studies mentioned above provide some accounts to the patterns of pitch range in Japanese, but mainly with a focus on specific pragmatic contexts from an experimental and

qualitative point of view. To the best of our knowledge, [12] and [13] are the first sociophonetics studies that explore the role of pitch range in Japanese using a large-scale database of spontaneous (adult) speech. In [13], results suggest both the importance of gender and register factors in the prediction of pitch range variations, and the influence of pitch range on the impression given by the speech to listeners. A result of interest in [13] was that pitch range for male speakers was observed to be wider than for female speakers. This is in contradiction with the wide-spread intuition that women have a wider pitch range, or that a wide pitch range is associated to feminine (or ‘gay-like’) speech [14, 15].

The issue that arises from the findings in [13] is the nature of this wider f0 range observed for male speakers. A wider pitch range being caused by a larger difference between minimum and maximum f0 values, we can postulate that male speakers either raise or lower their tonal targets when compared to females. This study investigates the nature of the gender difference observed in spontaneous speech in [13] using data from a large-scale spontaneous speech corpus. Specifically, we examine the effect of gender and register on the variations of f0 range, minimum and maximum values. The goals of this paper are as follows: (1) Investigate the nature of the difference in pitch range between male and female speakers in Japanese; and (2) define how Japanese speakers make use of f0 to express different levels of formality.

2. Methods

Data was retrieved from the Corpus of Spontaneous Japanese ([16], henceforth CSJ) a large-scale database of spontaneous speech. We extracted data from the “CSJ core”, which comprises 201 speech samples (about 162,000 seconds, 111 male, 90 female speakers, age range: 25-69 y.o.)

Gender and age are annotated in the corpus. The corpus also provides four different styles: (i) Academic Presentation Speech (A, N=70), a collection of recorded academic (conference) presentations; Simulated Public Speaking (S, N=107), recordings of solicited speeches about everyday life; Dialogue (D, N=18); and Reading (R, N=6). A, S and R are monologues, while D is a conversation between two speakers (M and F dyad, F and F dyad, 6 samples each). The three styles differ in terms of presence/absence of real audience and degree of formality. D and A involve a real interaction context between a speaker and an audience (one or several listeners), while in S there is no audience except for the recording staff. Regarding the formality, A is more formal than S and D. R has a different status in the way that it is not spontaneous speech but read speech.

The CSJ also comes with TextGrid files and a variety of annotations regarding speaker attributes such as gender, age, and other indexes regarding perceived characteristics of speech that were used for analysis.

F0 measurements were conducted based on the TextGrid files provided in the CSJ for each utterance that was defined as transcription units in [16]: utterances separated by “longer-than-200 ms” pauses. The pitch range (or f0 range) within each utterance is defined as follows:

$$\text{f0 range} = \text{maximum f0} - \text{minimum f0} \quad (4)$$

In addition to the raw data in Hertz, we also made use of the semitone scale for analysis on pitch (following [4, 5, *inter alia*])

in order to normalize the f0 data extracted from the CSJ that includes both male and female speakers. Indeed, [17] demonstrates that the semitone scale is the most appropriate for intonational equivalence and [18] shows that proportional variations in pitch are more related to perception than absolute changes. The semitone scale is a logarithmic scale that divides changes in frequency on one octave in 12 equal intervals that allows to normalize the data, so that rather than equivalent differences in absolute frequency (that should be different for male and female speakers) it is equivalent proportional differences that are evaluated.

For each utterance, data extraction was automatized using a Praat [19] script in order to obtain the following f0 data in both Hertz and semitone: f0 mean (Hz), f0 minimum (Hz), f0 maximum (Hz), f0 range (Hz), f0 mean (st), f0 minimum (st), f0 maximum (st), f0 median (st), f0 range (st).

After manually checking the data, utterances for which the pitch value could not be obtained by Praat (e.g. too short, no f0 data), and errors, were excluded from the analysis. In total, we analyzed 60,271 tokens. The statistical significance of the distributions was tested using R [20].

3. Results

3.1. Pitch and gender

Although [13] analyzed pitch range by gender using the CSJ, because we extracted data for the CSJ with a different method and have a different number of tokens, we replicated the analysis with our data. The distribution of pitch range by gender in the present data is illustrated in the box plot in Figure 1. The mean value is indicated by the cross on each box.

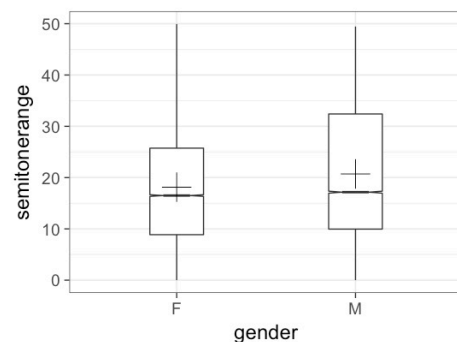


Figure 1: F0 range distribution by gender

As shown in Figure 1, pitch range is wider for male (mean=20.70) than for female (mean=18.12) speakers with a wider range of variations. This difference in pitch range for male and female speakers was shown to be significant by an independent-samples t-test ($t = -26.321$, $p < .001$), which is consistent with the results in [13].

The interesting aspect of this result comes from the contradiction we observe in previous studies for other languages and the widespread view that women’s speech has more f0 variations (wider pitch range is associated with a more “feminine” speech in [14, 15, 21]).

A look at the f0 mean, minimum and maximum values for both speaker groups presented in Table 1 and Figure 2, indicates that f0 values are higher (min, mean, and max) for female speakers than male speakers. However, the difference between female and male speakers is reduced for maximum pitch

(3.46st) when compared to minimum pitch (6.04 st). This suggests that the difference in pitch range between the two groups is caused by a lower minimum pitch for male speakers and a reduced difference in maximum pitch.

Table 1: F_0 values (min, max and mean) for male and female speakers.

| | min f_0 (st) | mean f_0 (st) | max f_0 (st) |
|---|----------------|-----------------|----------------|
| F | 82.89 | 91.97 | 101.02 |
| M | 76.85 | 84.66 | 97.56 |

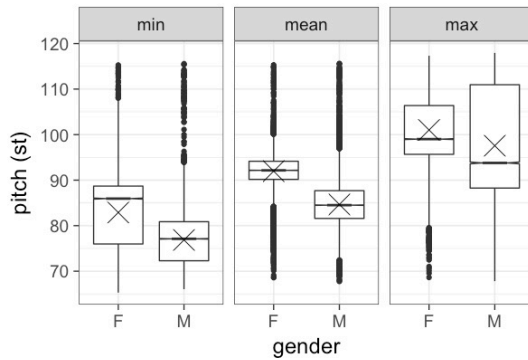


Figure 2: Distribution of f_0 values (min, mean and max) for male and female speakers. (X represents the mean value)

3.2. Pitch and register

We now turn to an analysis of the difference in f_0 range with regard to the register of the speech. The variation by talk register of the mean f_0 range value for men and women is illustrated in Figure 3. The four talk styles are ordered in formality order, from the most formal (R) to the most informal (D) ([22] *et seq.*).

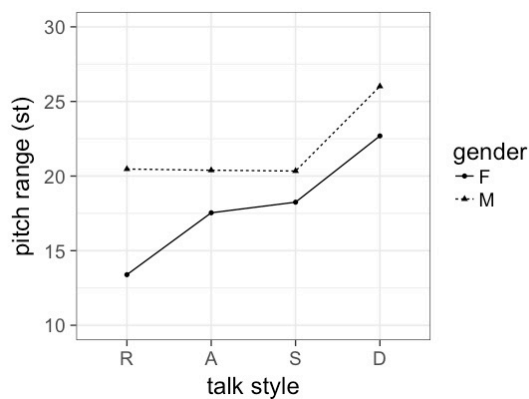


Figure 3: Variations in mean f_0 range values by talk style for male and female speakers.

As we can see in Figure 3, although both male and female speakers share the tendency to increase their pitch range as the level of formality decreases, the two speaker groups exhibit a different behavior from each other.

For female speakers, we observe a clear increase in the wideness of f_0 range from the more formal to the less formal talk style. A one-way ANOVA indicated that the talk style had a

significant effect on pitch range values ($F(3, 27464) = 228.7, p < .001$) and post-testing with the Tukey multiple comparison method indicated significant differences between all four talk styles, although values for A and S are similar.

For male speakers however, although statistical testing also points out a significant correlation between values of f_0 and the talk style ($F(3, 32798) = 118.3, p < .001$), post-testing suggests that only f_0 range in D is different from the three other groups ($p < .001$), while R, A and S do not significantly differ ($p = .98$).

These results are consistent with the findings in [13], in which authors interpret this difference as a difference in their orientation in communication. Men are more sensitive to the referential function that bears on information-oriented purpose (i.e. stylistic level, formality), which might have produced the distinction between D the more casual, and R, S and A, which are more formal. On the other hand, female speakers are said to be more sensitive to the affective function. In the present case, it refers to the presence/absence of audience or interaction. This accounts for the difference observed between D and R, while A and S have close f_0 range values. In order to investigate the nature of the gender difference in pitch range for each talk style, we now turn our attention to the detailed minimum and maximum f_0 data presented in Table 2 and Figure 4.

Table 2: Minimum and maximum f_0 values by talk style

| F/M | min f_0 (st) | max f_0 (st) |
|-----|----------------|----------------|
| R | 84.95/76.76 | 98.34/97.23 |
| A | 84.2/78.35 | 101.75/98.74 |
| S | 82.04/75.26 | 100.29/95.61 |
| D | 81.57/77.34 | 104.26/103.36 |

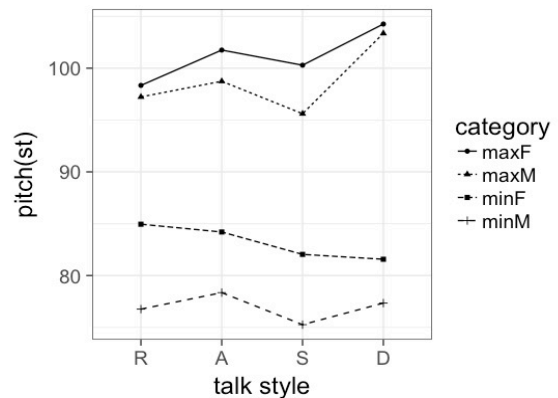


Figure 4: Mean values for minimum and maximum f_0 by talk style and gender.

For female speakers, the tendency for the minimum pitch (squares) is to go down when formality decreases. On the other hand, maximum f_0 (circles) has lower mean values for R and S than for A and D, where D is the highest. There was a significant effect of talk style on minimum ($p < .001$) and maximum ($p < .001$) f_0 . For male speakers, the effect of talk style on minimum (crosses, $p < .001$) and maximum (triangles, $p < .001$) f_0 was also significant. However, for minimum f_0 , post-testing indicated that pitch values in R and D are similar. Results for maximum f_0 are especially of interest as male speakers show f_0 values close to those of female speakers while their minimum f_0 stays lower. This accounts for the wideness

of pitch range in D for men. Furthermore, our results suggest that, in order to express a lesser degree of formality, the strategy for both speaker groups is a rise in f_0 (and not a lowering for male speakers, for example) and a wider pitch range.

Another observation that can be made on this data is the effect of the nature of the recordings on f_0 values. Indeed, S and R appear to always have lower values when compared to A and D. We propose that spontaneity: more spontaneous (S, R) vs. less spontaneous (A, D) might be responsible for the difference we observe here ([22] *et seq.*).

4. Discussion

Several issues arise from the findings of this study. In previous studies about F_0 range female speakers were shown to have a wider pitch range (e.g. English [14, 15, 21]). This is also in line with our intuitive judgment. However, our findings suggest that in Japanese it is the opposite: it is wider for male speakers.

It is in fact not uncommon to find such a discrepancy between the perceived pitch variation and its physical reality. Our results can be put into perspective with the body of research on speech development contradicting the traditional view that individuals with Autism Spectrum disorder (ASD) speak in a “flat” or “monotone” fashion. This view is based on the differences in social perception, cognition [26], and social expressivity [27] exhibited by individuals with ASD compared to non-ASD individuals. However, research on the acoustic properties of prosody in individuals with ASD point out the opposite pattern: ASD individuals have characteristic abnormal sentence stress and intonation pattern, and exhibit greater f_0 range [28], [29]).

In the present case, speakers in the CSJ (who reported no specific speech or cognitive impairment) exhibit an unexpected pattern, which suggests that in Japanese men can have a wider pitch range. This is especially observed in informal conversation (i.e., D). We suggest that the impression according to which women have a wider pitch range in Japanese is not a physical reality but originates in their tendency to speak with a higher f_0 register when compared to male speakers.

Another issue worth discussing is how Japanese speakers make use of f_0 to express formality. Ohala [30] and Gussenhoven [31]’s frequency code, posit a higher f_0 as a universal indicator of more formal and deferential speech (e.g. in Spanish, Mandarin, Korean and Spanish. See [32] and references cited therein for a review). In Japanese, however, previous research provides mixed results: in [33] and [34], results suggest that politeness is associated with a higher f_0 , in [35] results are mixed, and in [36] it was higher for informal speech, going against the predictions of the frequency code. Our results are consistent with those of [36] in the way we observe both a wider pitch and an increase in max f_0 in informal speech (D). It also supports those of [37], an experimental study on Korean, which found that Korean native speakers lower their average f_0 and f_0 range in formal situations.

Contrary to predictions in the frequency code theory [30] [31], our study seems to suggest that formality is not associated with a higher pitch in Japanese, but with a narrower pitch range and lower f_0 values. Informal speech, on the other hand, is characterized by a higher maximum pitch and a wider pitch range. This result is not surprising if we take the nature of the language into account. As introduced in Section 1, Japanese has a lexical pitch accent, and as such, in order to maintain the contrast between lexical items, the inventory of intonational

tones that speakers can make use of is reduced. Prior work, however, indicates that variation is possible within an allowed range [13]. If we consider that maintaining canonical forms, both segmentally and prosodically, is a property of formal speech, then it is not surprising to observe a narrower pitch range in a formal situation, speakers being more sensitive to the correctness of speech.

Informal speech in Japanese, on the other hand, is associated with a variety of reduction processes at both the segmental and syntactic levels. For example, the interrogative particle ‘*ka*’ is often omitted, and replaced by a rising intonation sentence-finally in informal speech. In the light of such properties of the language, it is not fortuitous that in informal speech, in which deviations from canonical forms are more accepted, we observe a wider pitch range. We can also relate these observations with findings in [13], in which wider pitch range is perceived by native listeners as less natural.

Lastly, [37] proposes that the cross-linguistic association between a higher pitch and politeness might not be relevant in languages like Korean that make use of honorifics in specific formal contexts as a form of social indexing, which differs from the type of politeness that can be observed in English for example. The similar nature of formality in Japanese and Korean suggests that the frequency code theory might not be applicable to these two languages, which is consistent with the lowering of f_0 and f_0 range observed in this study.

5. Conclusion

This paper investigated the differences in f_0 patterns between male and female speakers using a large-scale database of spoken Japanese. Contrary to the intuitive judgment that cross-linguistically female speakers have a wider pitch range than male speakers, previous studies on Japanese spontaneous speech indicate the opposite pattern. This study confirmed this gender difference, and found that it might be due to a tendency observed in male speakers to raise their maximum f_0 . Register was also found to be crucial in predicting f_0 and f_0 range patterns. Indeed, we observed gender-based differences when examining the four talk styles separately. The observed patterns support findings from previous studies, which suggested that men are more sensitive to referential functions, while for women it is the affective ones that play a significant role.

This study also provides new insights on the nature of (in)formality in Japanese with regard to pitch range. Our results suggest that formality in Japanese is not associated with a higher f_0 (as found in other languages). Specifically, in our data it is informal speech that has higher f_0 values, as well as a wider pitch range. This was observed for both male and female speakers. Formal speech, on the other hand, is characterized by a narrower pitch range and lower f_0 values, which is consistent with the nature of the language: the use of lexical pitch accent restricts the inventory of intonational tones that Japanese speakers can use.

The role of f_0 in the expression of formality in Japanese spontaneous speech is an understudied topic. Although this study offers some preliminary findings, more investigation is necessary in order to clearly define how speakers make use of f_0 in formal/informal situations. Future studies will investigate in particular the perception that native speakers have of specific f_0 patterns with regard to formality and how it can be related to the cultural aspects in communication in Japanese [10, 11].

6. References

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