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Acoustic Expression of Japanese Special Morae in Singing from the Viewpoint of Word-Setting and Reflection for Electroacoustic Music

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Abstract

In the Japanese language, geminate obstruent /Q/ and moraic nasal /N/ have independent sounds of subsequent consonants, and each consists of an independent phoneme and constitutes a unit of one mora. In Japanese songs, each note generally has a mora set to it, but for special morae including geminate obstruent and moraic nasal, there are two cases. One is that a note has only one special mora and the other is that a note has an independent mora and a special mora. These two word-setting cases often appear in the same piece of music. As for singing, it is thought that the selection of these cases depends on the musical characteristics, such as pitch, duration and dynamics, of the passages concerned. Within electroacoustic music, Toru Takemitsu's *Quiet Design* and Joji Yuasa's *Voices Coming* are works using human voice, and we can grasp the meaning of Japanese words in them. It is surmised that the works retain the characteristics of Japanese acoustic features in the process of composition.

In this study, some acoustic features of geminate obstruent and moraic nasal in singing lyrics varied with pitch and note value are examined, in comparison with those in reading aloud the same lyrics. I extracted some passages containing geminate obstruents and moraic nasals from a Japanese hymnal. I recorded the vocal data of seven master course students of vocal music using the software Praat on a personal computer. From the resulting audio data, including sound waves, sound spectrograms and formants, on Praat, I analyzed the musical characteristics.

As a result, as for both geminate obstruent and moraic nasal, differences in the word-settings are reflected in the degree of the overlapping preceding vowel's formant, and geminate obstruent contrasts greatly with moraic nasal in the case of overlapping. It is peculiar that in most cases, the duration of the geminate obstruent in singing is almost as long as that in reading aloud, while the duration of the moraic nasal in singing is unrelated to that in reading aloud. It is also peculiar that in the case of two morae in the note, the duration of the moraic nasal creates a unit for a subsequent beat.

I conclude that as for geminate obstruent, natural reading duration takes priority in music, while as for moraic nasal, the duration changes to create rhythm for the music. I also show the findings about retaining of Japanese acoustic features in electroacoustic music by analyzing acoustic features of geminate obstruent and moraic nasal in *Quiet Design* and *Voices Coming* based on obtained characteristics of them.

Background

It is known that languages can be classified into distinct rhythm classes, including “stress-timed” (e.g. English and Russian), “syllable-timed” (e.g. Italian and Spanish), and “mora-timed” (e.g. Japanese). This is based on the idea that the three types of languages maintain isochrony (equal interval timing) at different levels¹. The real timing is not in equal intervals; however, each stress, syllable, or mora makes a unit of metrical structure in each language. Japanese has short and long syllables. A short syllable consists of one mora and a long syllable consists of two morae. A mora is intuitively a unit of rhythm or timing. Morae are metrical units of traditional Japanese poetry. For example, haiku normally consists of a five-mora first line, a seven-mora second line, and a five-mora third line, for a total of seventeen morae. The short syllables are V (vowel), CV (consonant + vowel), and C/y/V (consonant + approximant + vowel). Each long syllable consists of two morae². The first morae are the short syllables. Only the following four types can be the second morae: V (vowels), /R/ (long sound), /N/ (moraic nasal), and /Q/ (geminate obstruent). We call these four types “Special Morae”. Among Special Morae, geminate obstruent /Q/, or ‘sokuon’, and moraic nasal /N/, or ‘hatsuon’, have independent sounds of subsequent consonants, and each consists of an independent phoneme and constitutes a unit of one mora. In Japanese songs, each note generally has a mora set to it, but for Special Morae there are two cases. One is that a note has only one Special Morae, and the other is that a note has an independent mora and an Special Morae. These two word-setting cases often appear in the same piece of music. It is regularly commented that this co-existence cannot be explained from a linguistic point of view³. As for singing, it is thought that the selection of these cases depends on musical characteristics such as the pitch, duration, and dynamics of the passages concerned. And, the differences between these two cases show different acoustic features in singing.

On Japanese acoustic features, many of the previous studies investigated permissible timings and thresholds of duration in the fields of acquisition of the Japanese language. However, there were few studies in other fields. And, there were no studies researching acoustic expression in singing passages including /Q/ and /N/ or researching the differences of word-settings of the Special Morae from the viewpoint of acoustic expression.

Within electroacoustic music, Toru Takemitsu’s *Quiet Design* and Joji Yuasa’s *Voices Coming* are works using the human voice, and we can grasp the meaning of Japanese words in them. It is surmised that the works retain the characteristics of Japanese acoustic features in the process of composition. From the viewpoint of listening comprehension of Japanese, it is presumed that the treatment of /Q/ and /N/, which is important in linguistic acquisition, plays an important role.

Aim

The aim of this study is to find out how to reflect the differences in the word-settings from a musical point of view and to research the roles that the special morae play in vocal music in Japanese, and how these acoustic features are reflected in the electroacoustic works.

¹ Timothy J. Vance, *The Sounds of Japanese*, Cambridge (UK), Cambridge University Press, 2008, pp. 121-122.

² *Ibid.*, p. 118.

³ Haruo Kubozono (窪蘭晴夫), “Kayo ni okeru Mora to Onsetsu”, in *Bunpo to Onsei (Speech and Grammar) II*, Tokyo, Kuriosio, 1999, p. 253.

Japanese Special Morae from the viewpoint of Word-Setting

First, the acoustic expression of /Q/ and /N/ in Japanese vocal works is examined by analyzing the vocal data of students of vocal music.

Method

Selection of pieces of music

Some passages containing special morae from a Japanese hymnal (Nihon Kirisuto Kyodan Sanbika Iinkai, 1971) are extracted, in which there are many translated songs whose texts were put to the original music later. The preface says that the editors concentrated their efforts on coinciding the punctuation of the texts with that of music.

Recording

Recording was carried out at the Aichi University of the Arts. Seven master course students⁴ of vocal music both sang and read aloud the passages twice, and their vocal data was recorded using the software Praat (Version 5.4.12) (44100Hz, monaural). These students were requested to sing in the ideal Japanese singing formula.

From the resulting audio data, including sound waves, sound spectrograms and formants on Praat, the musical characteristics were analyzed.

Results

In this study, the vocal data of each one are analyzed from soprano (S), alto (A), tenor (T), and bass (B), assuming the possibility of difference in gender and voice.

Figure 1 shows an excerpt of these results. For each following items, the music score of the phrase is shown along with the output of Praat, the sound spectrogram, the pitch, and the intensity with added segmentation by myself. The yellow lines represent the intensity, and the blue lines represent the pitch.

⁴ The breakdown of seven people is as follows. Three sopranos, two Altos (mezzo sopranos), one tenor, one bass (baritone).

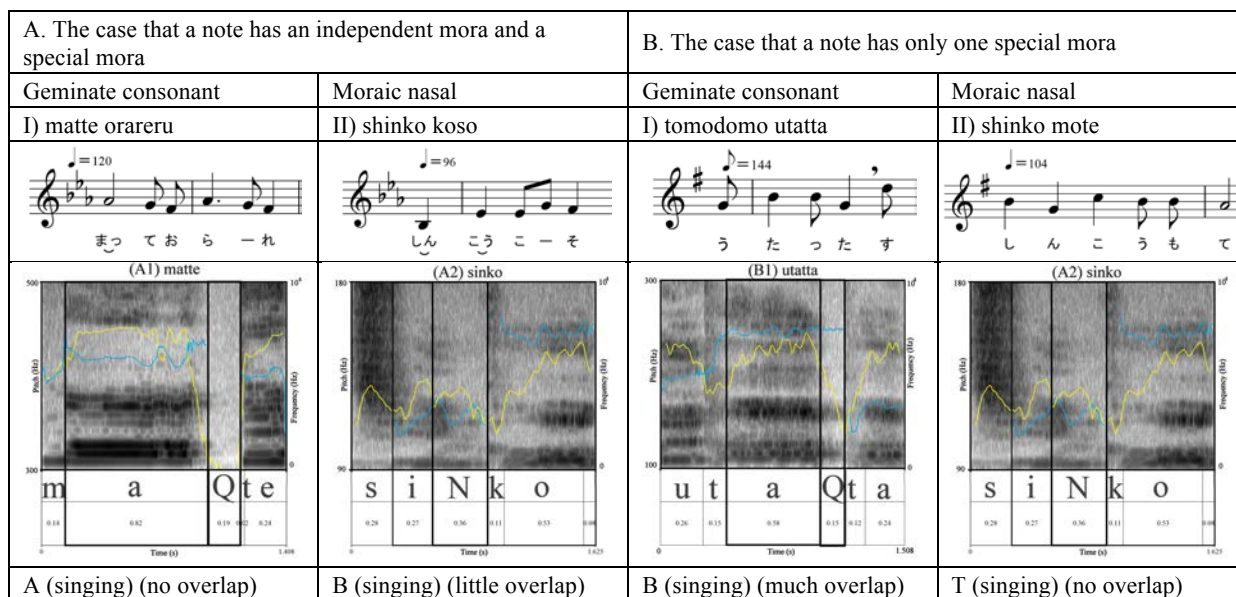


Figure 1: Acoustic analysis of /Q/ and /N/ in the light of differences between text-underlays⁵

The case that a note has an independent mora and a special mora

I) /Q/, the phrase of “matte orareru (the Savior is waiting)”

Except B, the /Q/ is sung as long as the duration when it is read aloud, and the rest of the note’s duration is sung with the preceding vowel /a/. As for B, the /Q/ is sung half a beat in time to the music. As for T and B, the formants of the preceding vowel overlap those of the /Q/, and as for S and A, they do not, both in singing and in reading aloud.

II) /N/, the phrase of “shinko koso (my faith, it is an oaken staff)”

As for all, the ratio of the duration of the preceding vowel /i/ to that of /N/ is 2:3 in singing. The duration of the /N/ is half of the subsequent mora, and it seems that the /N/ makes the music rhythm at half a beat. The duration of the /N/ in singing is over two times as long as that in reading aloud. Both in singing and in reading aloud, the formants of the preceding vowel overlap those of the /N/, and the degree of overlap varies in each.

The case that a note has only one special mora

I) /Q/, the phrase of “tomodomo utatta (And the angels echoed around the throne)”

The pitch of the preceding vowel /a/ does not differ from that of the /Q/. As for S, A, and T, the /Q/ is sung as long as the duration when it is read aloud and the rest of the note’s duration is sung with the preceding vowel /a/. As for B, the /Q/ is sung half as long as the preceding mora, that is, the full note length of the /Q/. For all the cases, there are no acoustic features to beat the time. As for A, T, and B, the formants of the preceding vowel overlap those of the /Q/, and as for S, there seems no overlap.

II) /N/, the phrase of “shinko mote (climb high with faith)”

The pitch of the preceding vowel /i/ differs from that of the /N/. The duration of /N/ is almost as long as that of the preceding vowel /i/. As for S, T, and B, the ratio of the duration of the /N/ and subsequent consonant to subsequent vowel is 1:1, and as for A, it is about 2:3. The duration of the consonant of the subsequent mora seems to be front-loaded to the note of the /N/ in order to secure the beat time of the subsequent note with vowel. The degree of overlap

⁵ This figure is an excerpt from Momiyama (2017).

of the preceding vowel and the /N/ varies in each case, but there is a marked distinction between them. It is also noticeable that the intensity falls a little at the /N/.

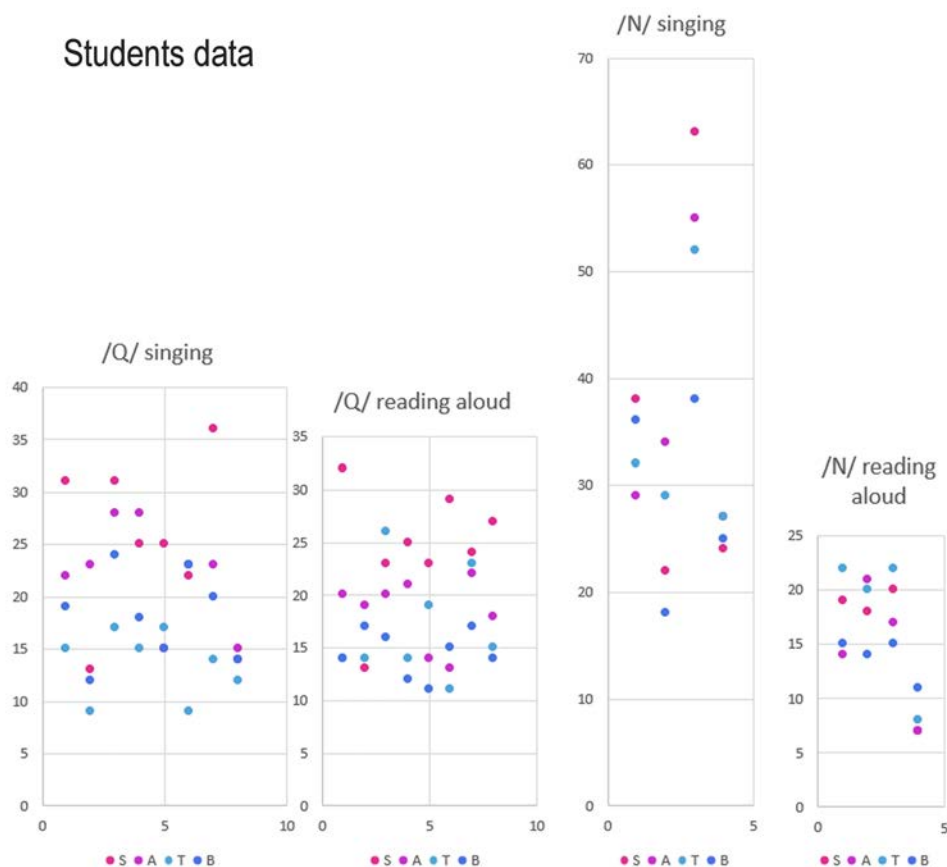


Figure 2: The plotting of the duration of these /Q/ and /N/ in singing and reading aloud

Distribution diagram of duration

Figure 2 shows the plotting of the duration of these /Q/ and /N/ in singing and reading aloud. Pink is soprano and blue is bass. The vertical axis shows the duration, and the horizontal axis shows each word. /Q/ is almost unchanged in singing and reading aloud, while /N/ is slightly shorter than /Q/ in reading, but singing /N/ is much longer than /Q/. And there seems to be a little significant difference in gender and voice: /Q/s of soprano are longer, and /Q/s of male are shorter.

Findings

To summarize the characteristics of /Q/, it is divided into three cases (Figure 3).

- a) The /Q/ is sung as long as the duration when it is read aloud, and the rest of the note's duration is sung with the preceding vowel;
- b) The duration of the preceding vowel is almost equal to that of /Q/, and it consists of half a beat;
- c) On the note of the /Q/, preceding vowel is sung before the /Q/, and the latter isn't longer than the former.

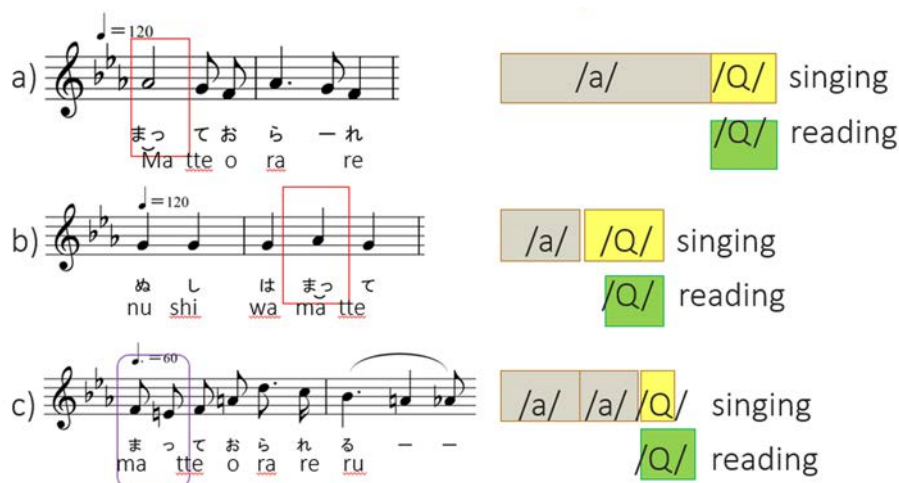


Figure 3: The characteristics of /Q/

Table 1 shows the summary of the characteristics of special morae. As for /Q/, while in the case of two morae in the note, the formant transitions are clear in varying degrees, and in the case of only one special mora in the note, both the preceding vowel and /Q/ are sung in the note, and the formants of the preceding vowel overlap those of the /Q/. On the other hand, as for /N/, they are just the opposite.

	A. The case that a note has an independent mora and a special mora	B. The case that a note has only one special mora
/Q/ (natural reading duration takes priority in music)	the formant transitions are clear in varying degrees	both the preceding vowel and geminate consonant are sung and the formants overlap
/N/ (creates a unit for a subsequent beat)	the formants of the preceding vowel overlap	the formant transitions are clear

Table 1: Differences in Acoustic Expression of Singing between Text-underlays of /Q/ and /N/

It is peculiar that in most cases, the duration of the /Q/ in singing is almost as long as that in reading aloud, while the duration of the /N/ in singing is unrelated to that in reading aloud. It is also peculiar that in the case of two morae in the note, the duration of the /N/ creates a unit for a subsequent beat. But as for /Q/, this sometimes applies too.

In this way, it is proven that the acoustic characteristics of /Q/ make quite a contrast with that of /N/; as for /Q/, natural reading duration takes priority in music⁶, while as for /N/, the duration changes to create rhythm for the music.

Reflection for Electroacoustic Music

Within electroacoustic music or tape music, Joji Yuasa's *Voices Coming* (1969)⁷ and Toru Takemitsu's *Quiet Design* (1960)⁸ are works using human voice⁹, and we can grasp the

⁶ This /Q/'s characteristics might be related to Japanese 間. I would like to make it a future issue.

⁷ 湯浅譲二 《ヴォイセス・カミング》.

⁸ 武満徹 《クワイエット・デザイン》.

⁹ Koji Kawasaki (川崎弘二), *Nihon no denshi ongaku*, Tokyo, Aiikusha, 2009, p. 5; Toru Takemitsu (武満徹), *Complete Takemitsu edition 5, Popular songs, tape-music, music for the theater, radio and TV, addenda*, Tokyo, Shogakukan, 2004, p. 65.

meaning of Japanese words in them. This study examines how these works retain the characteristics of Japanese acoustic features.

Method

The acoustic expression of /Q/ and /N/ in these works is examined by analyzing the recording data in the CDs¹⁰. For these CDs, those containing /Q/s and /N/s in the phrases in which we can grasp the meaning of Japanese were extracted and analyzed with Praat. As analysis data, the CD sounds loaded as wav.files on the PC were used. This output data is difficult to analyze on formant, intensity, etc. because some sounds overlap variously. Thus, only the duration of special morae are focused on in this paper.

Results

Voices Coming

Voices Coming is divided into three parts¹¹. Of the three, ‘2 Interview’ is selected because only human voices are used and mechanical sounds and noises are not superimposed on it. In this part, Yuasa recorded questions and answers with his nine friends asked questions by him. He cut off meaningful parts from the tape and took out seemingly meaningless conjunctions, interjections, etc., and reconstructed with them¹².

In the following, the words heard as Japanese in the ‘Interview’ are analyzed.

In Figure 4 the duration of /N/s are plotted. The horizontal axis is the time (0 to 7’30”), and the vertical axis is the duration. Initially, it is between 0.05 and 0.10” but gradually spreads and finally ends at 0.05 to 0.10”.

In Figure 5 the duration of /Q/s are similarly plotted. These are somewhat longer in duration and stay within the range of approximately 0.07 to 0.19”. There are many /Q/s of 0.11”. At first, the range is narrow, widening gradually, and the last is gathered around 0.10”.

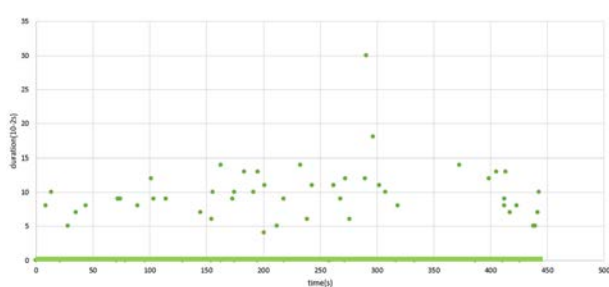


Figure 4: /N/ in *Voices Coming*

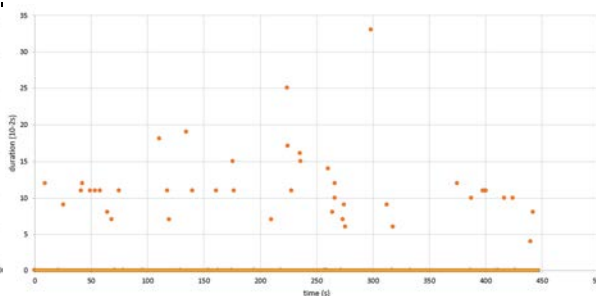


Figure 5: /Q/ in *Voices Coming*

Figure 6 is obtained by overlapping the preceding two graphs. In addition, asterisks represent the female voices; the red is /Q/s; and the green is /N/s. And the backgrounds of the parts of the interviewer are colored yellow. The plots with long duration are almost all those of female

¹⁰ Joji Yuasa (湯浅譲二), “Voices Coming” (NHK Electronic Music Studio), on *Joji Yuasa Piano Works and Tape Music*, Tokyo, Columbia Music Entertainment, CD, 1975 ; and Toru Takemitsu (武満徹), “Quiet Design”, on *Complete Takemitsu edition*, Tokyo, Shōgakukan, CD, 2002-2004.

¹¹ ‘Tele-Phono-Pathy’ (0’00”-6’47”), ‘Interview’ (6’47”-14’10”), ‘A Memorial for Two Men of Peace, Murdered.’ (14’10”-20’31”).

¹² Joji Yuasa (湯浅譲二), *Jinsei no nakaba : ongaku no hirakareta chihei e*, Tokyo, Keio Gijuku Daigaku Shuppankai, 1999, pp. 376-379.

voices. In this blue part, four men and one woman speak alternately, but deviation of one female voice is greater than the overall variation of male voices. It is thought that the composer has arranged a female voice with a different rhythm from the male voices. There is only a little difference between /Q/ and /N/, so it is considered to play the same role as “making rhythm” seen previously (section 3.3.). In detail, they seem to form arches; the first part is fast, then slow, and then fast, and so on. It finishes in 0.10”, and it can be seen that 0.10” is a base duration.

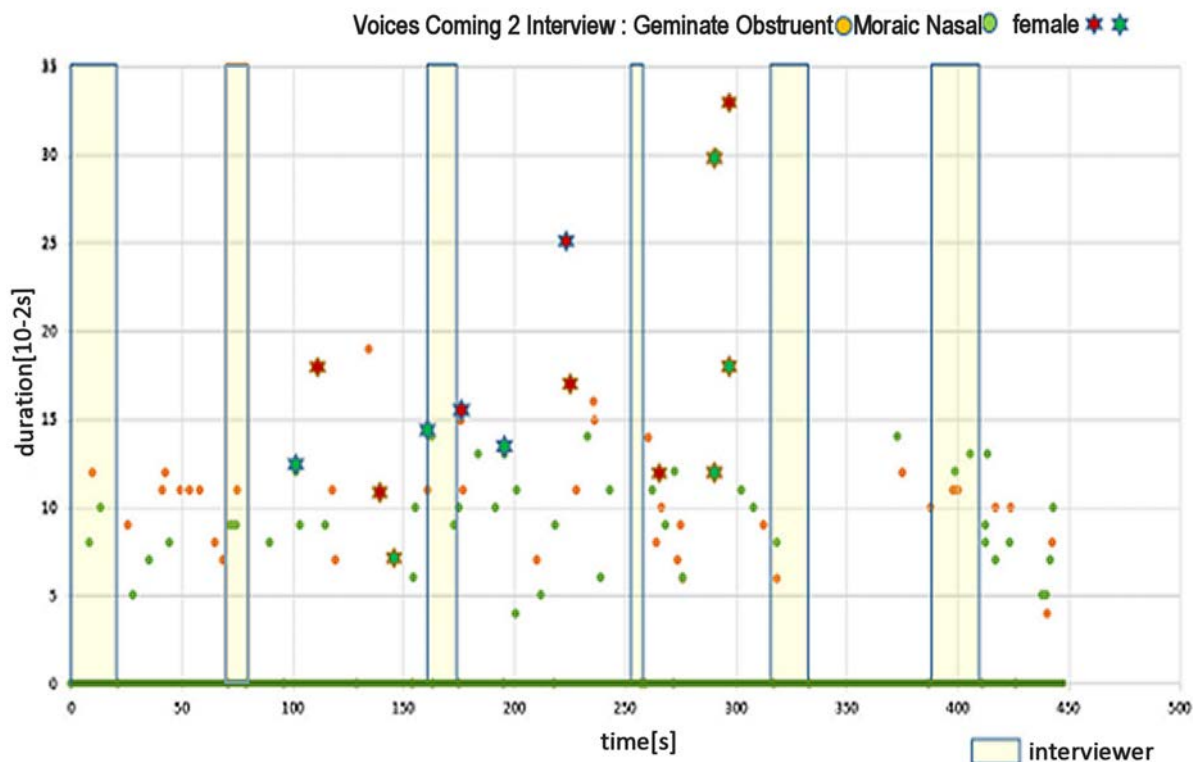


Figure 6: Overlapping /N/ and /Q/ in *Voices Coming*

In Figure 7, Figure 6 is compared with the graph of the student data studied previously. Students’ graphs and *Voices Coming* graphs are arranged on the same vertical axis. It can be seen that the students’ special morae are longer than those of *Voices Coming* overall. Although there are many short ones, it can also be seen that the *Voices Coming* data are not over the distribution of student data.

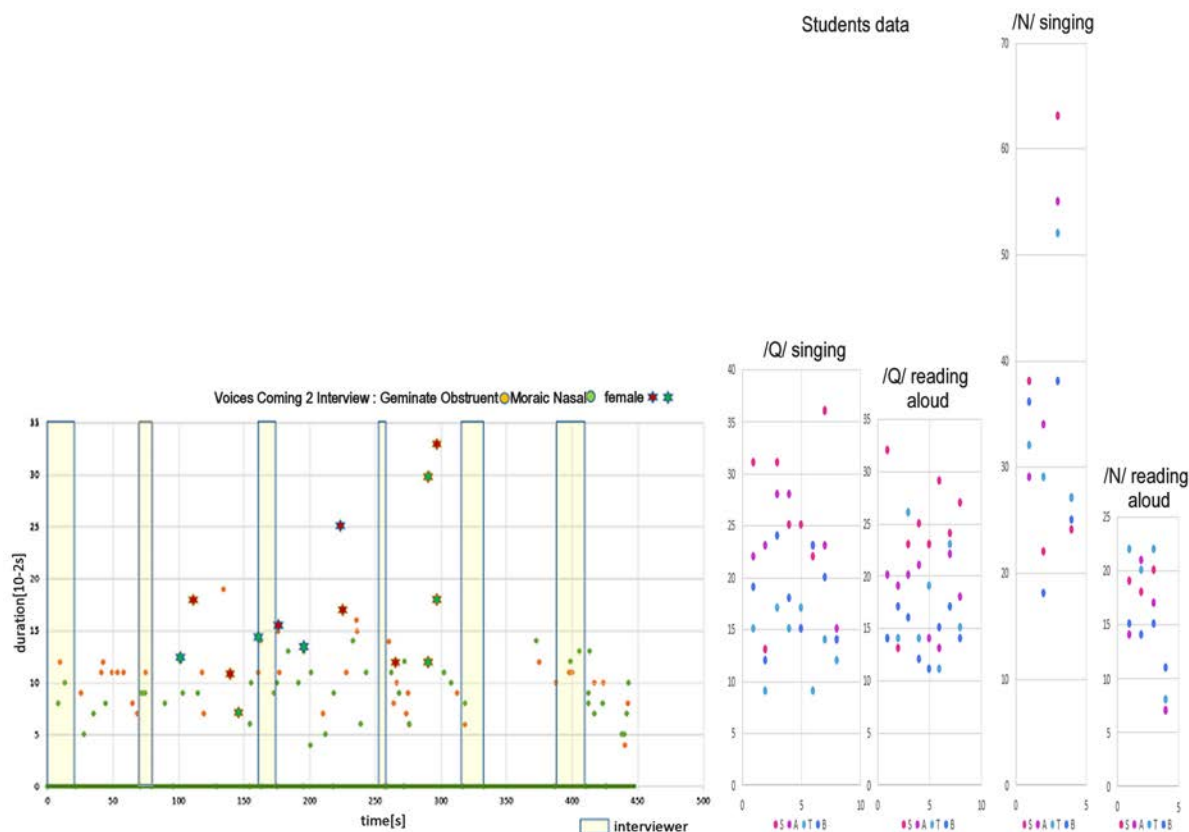


Figure 7: *Voices Coming* graphs and Students' graphs are arranged

Then, the vertical axis of the *Voices Coming* graph is doubled, and it can be seen that the distribution is almost the same as those of student graphs.

Thus, in *Voices Coming*, it is thought that raw data is processed to about half the speed¹³. As for the female voices, it is thought that making a slow rhythm like /N/s in singing and superimposing on the fast male voices make the layers of music.

Quiet Design

As for *Quiet Design*, the utterances are a few, and only 2 phrases could be extracted for /Q/. There is too little data to consider; however, there is an attempt at comparing these with the data of *Voices Coming*.

In Figure 8, the *Quiet Design* graph is aligned with the same axis as the previous graph; *Quiet Design's* /Q/ is within the range of the students', and it is within the range of female voice duration in *Voices Coming*. It is thought that these /Q/s approximate to the original duration in the process of composition.

¹³ Although Yuasa says that he didn't deform the voices so much as Tape music in the 'Interview' (Koji Kawasaki (川崎弘二), *Nihon no denshi ongaku*, Tokyo, Aiikusha, 2009, p. 52), surely he did deform them.

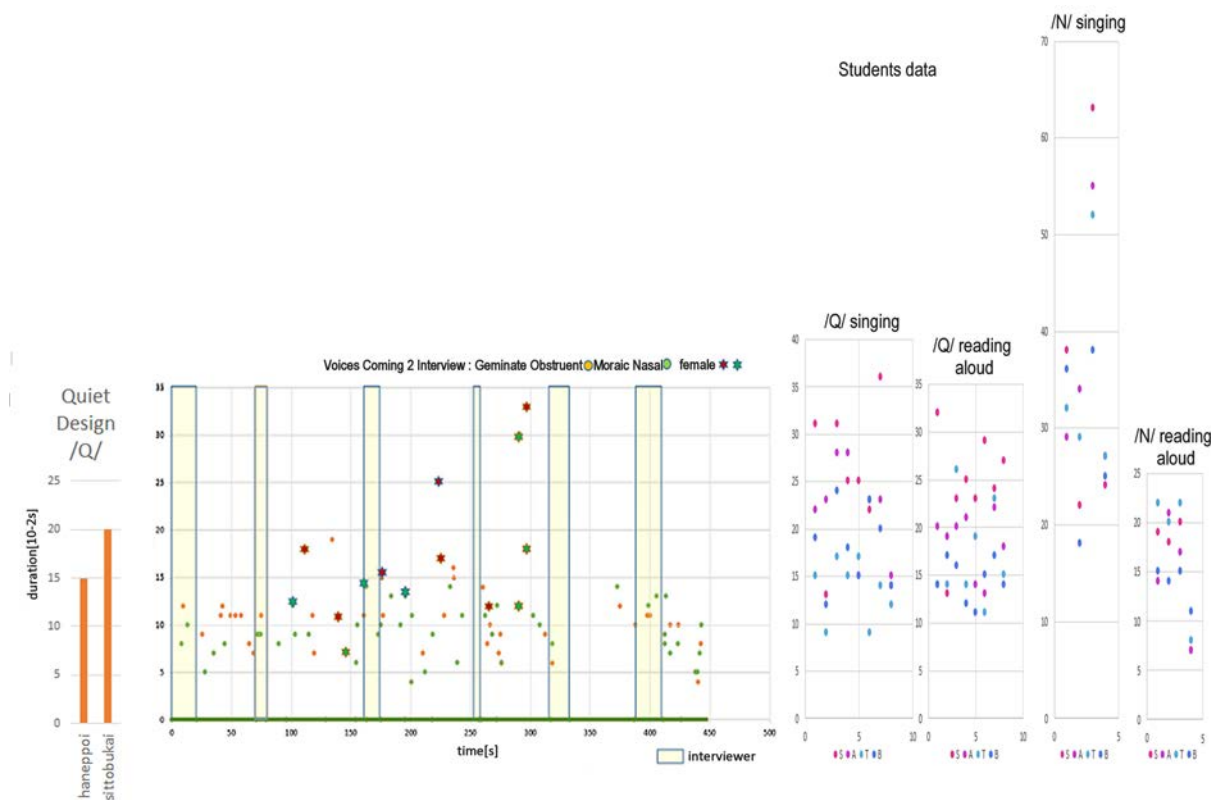


Figure 8: The *Quiet Design* graph is aligned with the same axis as the previous graph

Thus, in terms of the phrases whose meanings of Japanese we can grasp in *Voices Coming* and *Quiet Design*, the durations of special morae are mostly about the same or up to half as long as those in live singing and reading aloud.

It is thought that they make some musical rhythms by changing the duration, and superimposing them makes layers of the music. It seems peculiar to make the longer duration of female voices.

Conclusion

In this way, it is proven that as for /Q/, there are two cases in which it gives priority to the duration of itself and in which it creates a rhythm by changing the duration, and /N/ plays a role of creating a rhythm. In electroacoustic music, by processing the duration, the special morae play the roles of creating the rhythm without losing the meanings of Japanese. That is, processing the duration makes the speaking data work like singing data. And superimposing them makes layers of the music.

In the future, I would like to address the following issues: further analyses of data, survey real songs in other genres, analysis using music scores with the value of notes manipulated, and obtain useful results for singing voice synthesis and singing support.

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