Can't the Nasal Sequence [nn] be Regarded as a Geminate in Japanese?

Hiromi Otaka

1. Introduction

It has been controversial among phonologists whether geminates are phonologically one prolonged single consonant or a duplication of two identical segments belonging to different syllables (e.g. [tt], [pp], [kk], [ss], etc). Putting this controversy aside, the researchers have observed 16 kinds of geminates all told in Italian for example ([bb], [ttʃ], [dd], [ddʒ], [ff], [gg], [ll], [pp], [rr], [ss], [tt], [tts], [vv], [zz], [mm], [nn]), while 11 kinds in modern Japanese[1] ([kk], [ss], [ʃʃ], [tt], [tts], [ttʃ], [pp], [dd], [ddz], [ddʒ], [gg]). In this paper let us shed a light on the nasal sequence [nn] in Japanese as another possible geminate along with the 11 kinds listed above.

Both Japanese and Italian have the nasal sequence [nn] in common, but only the Italian one is now regarded by many researchers as a geminate. It is because the Japanese [nn] as in [kanna] ('plane'), [tonneru] ('tonnel') has been regarded phonologically as /Nn/, i.e. the first segment /N/ is thought to be a mora phoneme as a coda that can occur word-finally and before any different consonant or vowel as in /seN/ ('thousand'), /seNtaku/ ('laundery'), /seNiN/

1) Voiced geminates occur only in loanwords in Japanese.

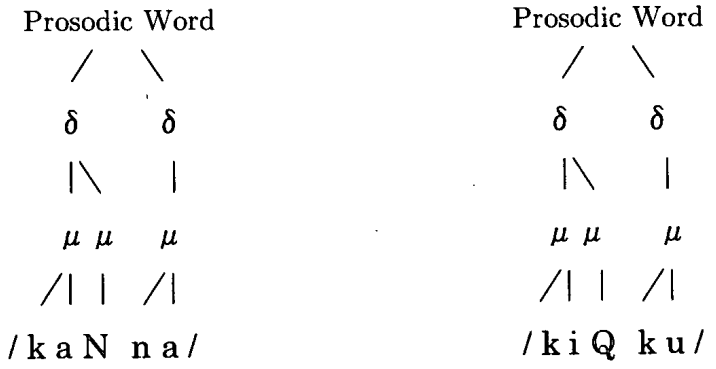
('sailor'). This is very different from /Q/[2] as the first segment of the approved Japanese geminates in that /Q/ never occurs word-finally. Thus, this difference in phonotactics between /N/ and /Q/ makes us assume that there must be a distinct boundary between the coda /N/ and the following onset /n/ from a prosodic standpoint of view. In contrast, it is not easy to demarcate distinctly between the two segments of the geminates with a /Q/ because the two segments (i.e. a /Q/ and the following one) seem to be connected or fused more tightly into one phonological unit. Therefore, many linguists have assumed further that /N/ can be, unlike /Q/, structurally independent of the following onset /n/ within the nasal sequence /Nn/. Once again, the boundary between the two segments of /Nn/ seems to be rather distinct as compared with the other geminates. In other words, /Nn/ never behaves as a single unit in Japanese. This is the reason why /Nn/ is currently not regarded as a geminate.

However, the duplicity of a segment is surely one of the characteristics of geminates on the other hand. In this sense, /Nn/ is obviously a kind of double consonant as described [nn] phonetically. Furthermore, in Japanese the first segment /Q/ of any geminate is thought to be given one phonetic mora as well as /N/. Then what is actually different between /Nn/ and the other 11 geminates in terms of gemination in Japanese? It seems that double consonants including /Nn/ are all produced and perceived in the same way with respect to timing in Japanese, and this may corroborate the geminicity of the sequence /Nn/ as well as the other approved double consonants. The following (Fig.1) is to illustrate the prosodic structures of /kaNna/ ('plane') and /kiQku/ or [kikku] ('kick') for example. Note that they can be equal in prosodic structure. Then, should /Nn/ really not be regarded as a geminate in Japanese? Can we argue that /Nn/

2) The first segments of all the geminates are all regarded phonologically as the mora phoneme /Q/ in Japanese because they are all transcribed as the specific syllabary 'つ' in the orthography.

is not a geminated consonant only because /N/ occurs differently from /Q/ in Japanese phonotactics? In fact, they have nevertheless one thing in common, i.e. they do not occur word-initially. Furthermore, in Italian, /n/ can occur both word-finally and before many kinds of consonants or vowels just like Japanese /N/. Thus, from the phonotactic standpoint of view, what is really peculiar to gemination in Japanese as a general rule seems to lie not in /N/, but in /Q/.

Fig.1: Prosodic structures of /kaNna/ ([kanna]) and /kiQku/ ([kikku]) in Japanese



The major goal of the present study is to examine whether or not the nasal sequence [nn](/Nn/) should be regarded as a true geminate in Japanese. To this end, let us compare the duration of [nn] with those of other geminates including the Italian equivalent [nn]. Will they be equal or significantly different? How about the durational ratio of [nn] to the whole /CVNnV/ sequence? If the duration of [nn] is equal to the mean duration of the other geminates, or at least significantly longer than the Italian counterpart[3)], it is possible to assume that /Nn/ may be produced in the same way as the other geminates with respect to timing, implying that /Nn/ could be a kind of geminate as well as the others.

3) The author has found so far that Japanese geminates are much longer than Italian geminates in terms of the ratio on the whole (forthcoming).

2. Phonetic characteristics of the mora phoneme /N/ in Japanese

Regarding the phonetic quality of the mora phoneme /N/, it has been well known among Japanese phonologists for a long time that it has various allophones depending on the phonological environment given to it (e.g. Hirata 1931). Hirata indicated the following five possible kinds of allophones of /N/ depending on the following sound, although he did not yet use the term 'allophone' at the time of 70 years ago.

/N/ → [m] (bilabial) : before [p, b, m]; e.g. [sampo] ('stroll')

/N/ → [n] (alveopalatal) : before [t, d, n, s, z, r]; e.g. [kanda] ('name')

/N/ → [ɲ] (hardpalatal) : before [ɲ]; e.g. [ʃinʧa] ('new tea')

/N/ → [ŋ] (velar) : before [k, g, ŋ]; e.g. [roŋgo] ('name of a book')

/N/ → [ɒ̃] (nasalized [ɯ̃]) : before [w]; e.g. [deɒ̃wa] ('telephone')

Many linguists have devoted themselves on this study after Hirata, and as a consequence the following two findings have been added to the knowledge on this issue (e.g. Martin 1952, Vance 1987, Nakajo 1989, etc.).

/N/ → [N] (post-velar) : word-finally; e.g. [peN] ('pen')

/N/ → nasalized vowel [ĩ] : before [i, e, ʃ, ç, j]; e.g. [keĩi] ('authority')

/N/ → nasalized vowel [ɯ̃] : before [ɯ , o, a, w]

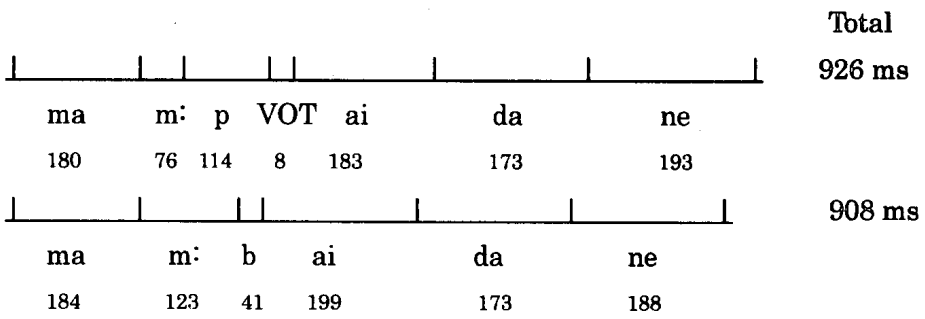
Since /N/ occurs as the coda of the preceding syllable, it has only the phase of implosion in the process of production as opposed to the onset /n/ with both explosion and implosion (Kindaichi 1958, Kuribayashi 1991). And this could be one of the phonetic cues for the Japanese listeners to distinguish /N/ from /n/ (e.g. /keNi/ 'authority' vs. /keni/ 'to the hair').

Another thing to be noted in this issue is a durational aspect of /N/. Han (1962) carried out a production experiment by using a sound spectrograph to mea-

sure the duration of /N/ in the three pairs of words [ʃimai] ('sisters') / [ʃimmai] ('untrained'), [ʃinin] ('dead person') / [ʃinnin] ('new appointee'), [niɲjo:] ('two lines') / [niɲɲjo:] ('doll'). As a result of the experiment, she argued that the mora nasal /N/ has the duration which is the same as that of a CV mora, because she found that the ratio of the onset nasal /n/ to the mora nasal /N/ was 1.0 to 2.6-3.0. This is the reason why /N/ has been thereafter called a 'mora phoneme.'

However, Sato (1990) expressed some misgivings about the results from Han's experiment, saying that what Han tested was only /Nm/, /Nn/, /Ng/([ŋŋ]) sequences in which /N/ was followed only by a nasal, and it was not mentioned in her analysis whether /N/ always had the same length regardless of the nature of the following consonant. Sato found that the length of /N/ actually varies according to the following consonant, i.e. it is shorter when followed by a voiceless consonant as in /maNpai/ ('full'), while longer when followed by a voiced consonant as in /maNbai/ ('ten thousand as much as'). The following Fig.2 is a quote from Sato (1990: p. 15) to show the proportional length of each mora of a pair of utterances tested by her; [mam:paidane] and [mam:baidane][4] for example (N.B. /N/ is manifested as [m:] here due to the following bilabial /p/ and /b/). Duration is shown in millisecond.

Fig.2: The proportional length of each mora (Sato 1990: p.15)



4) The meaning of this Japanese utterance is "It is full, isn't it?" In addition, /N/ is manifested as [m] before the labial /p/.

According to her, the reason why /N/ is shorter before a voiceless consonant than before a voiced one is that voiceless consonants are usually longer than voiced ones, thus temporal compensation occurs on /N/ depending on whether it is followed by a voiced or voiceless consonant. And this fact implies that as has been claimed by Homma (1981) and Port et al. (1987), temporal compensation does not occur within a syllable where /N/ occurs, but it does at the word level.

To be sure her observation above is phonetically correct, but it might be wrong phonologically. In mora-timed rhythm the duration of each CV syllable can actually differ depending on the quality of a given sound within the syllable. For example, voiceless onset consonants of a CV syllable make the whole syllable longer than the voiced counterparts do on the phonetic level. That is, phonetic moras are not quite isochronous in mora-timed language. Therefore, there still remains the possibility that at the phonological or psychological level the bimoraic syllables [pai] and [bai] in the example utterances above could nevertheless be regarded as equal in duration.

Furthermore, for the same reason as Sato's claim above that the duration of [m:] is shorter before [p] than before [b] could also be wrong phonologically, although it is undoubtedly correct phonetically or physically. Note the fact that the pause (114 ms) occurring between [m:] and [p] in [mam:paidane] was caused not by the constriction duration of the onset [p], but by a kind of anticipated voice assimilation[5] with the following voiceless consonant. In the VCV (C = a plosive or affricate) sequence, indeed we can assume that the duration of the plosive (or affricate) starts from the onset of its constriction duration, but we

5) The same thing can be said for High Vowel Devoicing in Japanese. The author has found that the high vowels /i/ and /u/ located between two voiceless consonants are devoiced not only completely, but also partially. Note that in the latter case the duration of the vowel is shorter than that of the vowel located in a different environment. Nevertheless, there is no difference in mora duration between the two CV syllables.

cannot do this for the [p] and [b] in the sequence of [m:p] and [m:b] because [m], [p] and [b] are all bilabials. There is no articulatory change between [m] and [p]/[b]. Thus, phonologically speaking, the duration of [m:] before [p] could nevertheless be regarded as equal to the one before [b], i.e. the pause after the [m:] followed by [p] should be counted into the whole /N/ as one phonetic mora in timing. The pause can be phonologically regarded as a devoiced part of /N/.

3. Experiment 1: Exploring the duration of /Nn/ in the /CVNnV/ sequence

3-1. Methods

The Japanese sentence /sono kaNna wa kaN to kana to kaNda desu/ ('The plane is called 'Kan,' 'Kana,' or 'kaNda.') was used as a stimulus for the present production experiment. As seen from the sequence above, this sentence contained three kinds of nasal targets, i.e. mora phoneme /N/ (/kaN/ and /kaNda/), onset /n/ (/kana/) and a succession of two nasals /Nn/ (/kaNna/). Through this experiment we examined whether or not the total duration of the mora phoneme /N/ in /kaN/ or /kaNda/ plus the onset /n/ in /kana/ is equal (or at least close) to that of the /Nn/ in /kaNna/. Theoretically they should be equal. We adopted the two words /kaN/ and /kaNda/ in search of a possible difference in the duration of /N/ between the two words, because as was pointed out by Sato (1990), the duration of /N/ before a voiced consonant might phonetically be longer than that before a voiceless one.

Furthermore, the durational ratio of the /Nn/ to the whole /CVNnV/ sequence was calculated in the same manner because this ratio is independent of speech rate. It is shown in percentage.

The informants who participated in this experiment were 19 native Japanese speakers studying at Kwansei Gakuin University in Japan. Their age varies from

19 to 21. Born and raised in Kansai (Osaka) area, all of them are Kansai dialect speakers. Since the stimulus sentence was short enough to memorize, they were asked to produce it without seeing the sentence as a text at the two different speech rates (normal and slow). Their utterances were recorded one by one on the PC in a quiet room, and subsequently analyzed by using a digital sound analyzer (Speech Station 2) to measure the duration of each nasal segment listed above.

3-2. Predictions

Since the nasal sequence /Nn/ comprises a nasal coda of the preceding syllable and a nasal onset of the following syllable, the duration of /Nn/ in /ka<u>Nn</u>a/ could be theoretically the same as the total of the mora phoneme /N/ in /ka<u>N</u>/ or /ka<u>N</u>da/ and the onset /n/ in /ka<u>n</u>a/. However, based on Sato's observation, the /N/ in /ka<u>N</u>/ followed by /t/ (/kaN/+/to/) may possibly be much shorter than the counterpart in /ka<u>N</u>da/. In this case, which /N/ will be closer to the /N/ in /<u>N</u>n/ in terms of duration?

In addition, the duration of /Nn/ could be shorter than those of the other geminates (e.g. [kk], [tt], [ss], [dd]) in which the first segments of them have traditionally been regarded as /Q/ in Japanese phonology, because /Nn/ is produced without stopping vocal cords vibration unlike the others containing a /Q/. For example, when producing a word /kaNna/ ('plane'), the speaker does not stop vibrating the vocal cords from the first vowel /a/ through the last vowel /a/ at all, while this is not the case when producing /kiQku/ ('kick'). It is possible that this articulatory difference between /Nn/ and /kk/ influences their actual durations because in the latter case with a /Q/ it must take the speaker some time to restart vibrating the vocal cords after producing the /Q/ in the sequence.

Last, regarding the comparison between the nasal double consonants in Ital-

ian and Japanese in terms of duration, the Japanese [nn] could be somewhat longer than the Italian counterpart because the first segment of [nn] is given one phonetic mora as /N/ in Japanese, while one phonological mora as /n/ in Italian. Once again, the former is a phonetic timing unit with isochrony, while the latter a phonological syllable-weighing unit.

3-3. Results and analyses

First of all, the mean ratio of [nn] (/Nn/) to the whole /CVNnV/ sequence turned out to be 35 percent irrespective of speech rate in Japanese. (All the data on the duration of each target segment of the utterance /sono kaNna wa kaN to kana to kaNda desu/ are shown in the Appendix at the end of this paper.) Comparing this figure (35%) with those of other geminates in Japanese, we can say that the duration of the nasal sequence is somewhat shorter than those of the other geminates overall. Based on the fact that the mean ratio of the Japanese voiceless geminates was 45 and 46 percent under normal and slow rate respectively, while that of the voiced ones ([bb], [dd], [gg], [ddʒ]) was 40 and 42 under the respective rate (Otaka: forthcoming), we can say that the result above totally agrees with our prediction proposed earlier.

The validity of the claim above was also confirmed by a statistical treatment. Regarding the ratio, Two Way ANOVA was run for the two independent factors, Geminate Kind (i.e. /Nn/ vs. the other kinds of double consonants with a /Q/), and Tempo. The following Table 1 is to show the statistical results from the Variance analysis.

Since the Pr(F) for Geminate Kind was 6.49E-19 and much less than the significance level of 0.05, the null hypothesis that there is no difference in the ratio between the two kinds of sequence, /Nn/ vs. the other kinds of geminate /CC/, was turned down. In other words, the mean ratio of /Nn/ was significantly

Table 1: Analysis of Variance (Fixed Effects Model)

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
Geminate Kind	1	2028.0889	2028	144.9378	6.49E-19
Tempo	1	4.2631578	4.263	0.304667	0.58268
Interaction	1	4.4547368	4.455	0.318358	0.57434
Residuals	72	1007.48315	13.99		

*Significance level = 0.05

lower than that of the other geminates. Regarding the Pr(F) for Tempo next, it was 0.58 much greater than 0.05. Accordingly, as was expected this result corroborated that the durational ratio was not in relation to Tempo irrespective of the quality of the double consonant. Furthermore, there was not seen any significant interaction between the two factors either (i.e. $Pr(F)=0.574 > 0.05$).

The result that the duration of /Nn/ was different from that of the other geminates overall might seemingly deny the geminicity of /Nn/. However, the difference must have been caused by that in the case of /Nn/ the vocal cords does not have to stop vibrating throughout the sequence at all, and that a constriction duration is not required for the articulation of /Nn/, either. This claim is also supported by the acoustic fact that in mora-timed rhythm CV syllables tend to become relatively long when the onset is a voiceless or plosive/affricate consonant as compared with its counterpart. Thus, it is still possible to phonologically assume that in terms of temporal measurement the nasal sequence is produced in the same way as the other geminates under mora-timed rhythm.

On the other hand, the duration of [nn] in Japanese turned out to be much longer than the counterpart in Italian, because the mean ratio of the Italian nasal geminate [nn] (5 samples) was 29 percent under both kinds of rate, normal and slow[6)]. Therefore, this result confirmed the validity of our prediction based on

6) This figure is quoted from "An acoustic investigation of geminate duration in Japanese and Italian" (Otaka: forthcoming).

the claim by past researchers that the first segment [n] (/N/) of the Japanese nasal sequence [nn] is produced on the basis of a phonetic mora with isochrony, while this is not the case for the Italian counterpart.

Regarding the possible difference in duration between the /N/ followed by a voiceless consonant and that followed by a voiced one, the mean duration of the former was 81 ms under normal rate and 91 ms under slow rate, while the latter was 108 ms and 131 ms respectively[7]. Thus, this result agrees with the finding by Sato (1990).

As for the duration of the [n] as onset, the mean duration of the [n] in [kana] was 44 ms under normal rate, while 49 ms under slow rate. Therefore, the total duration of the coda /N/ followed by a voiceless consonant and the onset /n/ is 125 ms under normal rate (81+44=125) and 140 ms under slow rate (91+49=140). Comparing these figures with the durations of the nasal sequence /Nn/ in /kaNna/ under the two different rates, interestingly they turned out to be very close to their counterparts (i.e. 125:122 under normal rate, 140:146 under slow rate). Accordingly, this result supports the traditional view that the nasal sequence [nn] consists of /N/ plus /n/ phonologically. However, in the case of the coda /N/ followed by a voiced consonant as in /kaNda/, it was much longer than the /N/ followed by a voiceless consonant. Thus, the total duration of the coda /N/ plus the onset /n/ amounted to 152 ms and 180 ms under normal and slow rate, respectively. Undoubtedly these figures seem to be too long as against the nasal sequence in /kaNna/ (i.e. 152:122 under normal rate, 180:146 under slow rate). This is probably because the constriction duration of the [d] in /kaNda/ was counted in the duration of the /N/ (See foot note 6).

7) However, strictly speaking, these durations may be somewhat unreliable because the closure duration of [d] is included in them due to the unclear boundaries between the offset of [n] and the onset of the VOT of [d] in the spectrogram. The closure duration varied from approximately 5 to 20 ms depending on each speaker.

Next is a discussion about the possible change in duration between the vowel V_1 followed by /Nn/ in the /$\underline{CV_1NnV_2}$/ sequence and that followed by the single /n/ in the /$\underline{CV_1nV_2}$/ sequence. According to Homma (1981), unlike the geminates in Italian[8], the geminates in Japanese do not have a shorter preceding vowel than single consonants. The vowel followed by a geminate with /Q/ gets rather prolonged in Japanese. And the same thing can be said for the vowel followed by /Nn/. Under normal rate the mean duration of the first vowel [a] in /kana/ was 42 ms, while that in /kaNna/ was 88 ms. That is, the latter was twice as long as the former. The same thing was observed from the comparison between the two vowels under slow rate. Under slow rate the mean duration of the first vowel /a/ in /kana/ was 50 ms, while that in /kaNna/ was 98 ms. That is, the former is a half of the latter in this case, too. This remarkable change in voewl duration is a noteworthy point as compared with the other geminates in Japanese.

Therefore, supposing that the coda /N/ always occurs in the second moraic position within a bimoraic foot as well as /Q/ in Japanese, we could assume further that the duration of the coda /N/ in the /$\underline{CV_1NnV_2}$/ sequence might become relatively short as compared with the word-final /N/ due to the preceding vowel V_1 that is prolonged under temporal compensation occurring within the foot of /$\underline{CV_1N}$/. In fact, as has been discussed, the actual duration of the /Nn/ in /ka$\underline{Nn}$a/ seemed to have been somewhat shorter than the theoretical duration of it that could be calculated on the basis of the duration of the coda /N/ followed by a voiced consonant (/kaNda/) and the onset /n/ (/kana/).

Let us turn to the analysis of /Nn/ duration based on a statistical treatment, i.e. Standard Deviation (STDEVP). Comparing the STDEVP of /Nn/ duration

8) Vowels in closed syllables are known to be phonetically short as compared with those in open syllables in Italian (Fava and Magno Caldognetto 1976, Vogel 1980).

(19 samples) with that of the other geminates containing a /Q/ (19 samples), it turned out that they were very close to each other. That is, the former was 3.40 and 4.60 under normal and slow rate respectively, while the latter 3.39 and 3.42. This result implies once again that the nasal sequence /Nn/ must have been produced by the informants in the same manner as the other geminates in terms of timing or rhythm. On the other hand, in Italian geminates it was 6.96 and 7.22 under normal and slow rate, respectively. This difference in STDVEP between Japanese and Italian also supports the claim, taking into consideration the greater stability of geminate duration in Japanese, that the first segment of a Japanese geminate is produced on the basis of a phonetic mora.

4. Conclusion

Regarding the nasal sequence [nn] (/Nn/) in Japanese, we found several things through the present production experiment with 19 informants. First of all, the durational ratio of /Nn/ to the whole /CVNnV/ sequence (i.e. 35%) turned out to be shorter than that of the other Japanese voiced geminates containing a /Q/ by 5 points, yet longer than that of the Italian geminate /nn/ by 6 points. This was exactly what we had predicted. Taking into consideration that stopping neither the vocal cords vibration nor the air stream in the vocal tract by using the articulatory organs (vocal cords, lips, tongue tip) is required for the production of the /Nn/ in /CVNnV/, it seems quite natural that /Nn/ be acoustically shorter than the other geminates consisting of a /Q/ plus the following onset consonant.

Indeed /N/ occurs quite differently from /Q/, (i.e. the former can occur both word-finally and before any kind of vowel or consonant unlike the latter), but this cannot be the decisive reason to argue that /Nn/ should not be regarded as a geminate in Japanese. Note that in Italian the segment /n/ can occur both word-finally and before many kinds of sound including an identical sound /n/

(e.g. *cinque, undici, ventuno, buongiorno,* etc.). This can be said for any other sounds that can be a segment of an Italian geminate. In this sense, what is truly peculiar or to be phonologically marked is the Japanese geminates with /Q/ rather than /Nn/.

The phonological substance of /Q/ within a geminate may be a kind of pause free from the vocal cords vibration, being given one phonetic mora as a timing unit. On the other hand, /N/ does not require the speaker to stop vibrating the vocal cords in production. Thus, they are totally different in terms of voicing in articulation. This is the reason why /Q/ does not occur word-finally unlike /N/. /Q/ cannot be acoustically conspicuous at the end of a word.

Nevertheless, the mora phonemes /Q/ and /N/ can both be the first segment of a Japanese geminate, being variously manifested on the phonetic level as an assimilated sound with the following onset consonant because of Regressive Assimilation. As has been discussed already, /Q/ is manifested as [p], [k], [t], [s], [ʃ], [ts], [tʃ], [d], [dz], [dʒ] or [g], while /N/ as [m], [n], [ɲ], [ŋ], [ɒ], [N] or a nasalized high vowel depending on the following sound. On the other hand, this is not the case for Italian geminates. In Italian the first segment of any geminate is not the sound manifested by Regressive Assimilation. Therefore, we can conclude that Japanese geminates are phonologically very different from Italian ones, although phonetically they appear to be the same, i.e. a duplication of identical segments. Once again, Regressive Assimilation is not involved in Italian geminates.

Last but not least, regarding the duration of the vowel followed by /Nn/, it turned out to be much longer than the counterpart followed by a single /n/. In fact, the former was twice as long as the latter. This is peculiar to /Nn/ as compared with the other geminates with /Q/, but seems to support the validity of our hypothesis that /N/ is phonologically put in the second moraic position within the Bimoraic Foot as well as /Q/ in Japanese. That is, the vowel before

/Nn/ can become relatively longer because of temporal compensation occurring within the domain of the foot consisting of the sequence /CVN/ with the result that the duration of the /N/ in /Nn/ becomes in turn shorter to compensate for the increase in the duration of the preceding vowel. This might be the reason why /Nn/ is shorter even than the geminates consisting of a /Q/ plus a voiced onset in Japanese.

Appendix: Data on the duration of each segment of the Japanese utterance '*Sono kanna wa kan to kana to kanda desu.*' produced at two different kinds of rate (normal and slow).

<Normal rate>

Sequences	/kaN/	/kaN/+/to/	/kaNda/	/kana/	/kana/					/kaNna/					
Segments / Informants	/N/	Pause after /N/	/N/	/n/	CD	/k/	/a/	/n/	/a/	CD	/k/	/a/	/Nn/	/a/	Whole
A	63	77	100	63	30	35	47	51	65	41	28	89	122	51	337
B	71	73	96	56	35	24	59	49	65	30	26	87	130	48	325
C	71	43	98	49	53	33	35	39	61	65	49	71	116	58	370
D	67	41	106	57	57	51	39	47	59	63	28	106	100	57	358
E	77	73	110	53	35	35	49	43	59	45	28	81	138	77	382
F	67	51	104	45	29	41	49	41	70	43	33	79	136	75	370
G	87	45	111	47	34	59	40	42	99	51	36	87	121	73	379
H	89	53	118	53	43	41	36	42	77	55	34	79	113	71	365
I	85	49	109	55	41	24	43	36	63	55	26	89	128	65	369
J	71	63	103	57	47	36	41	45	63	49	38	89	121	53	359
K	83	43	97	67	39	20	51	24	63	32	22	89	101	59	312
L	83	49	105	47	22	34	59	36	63	36	24	103	118	69	353
M	61	41	83	61	55	43	33	37	65	67	24	98	114	47	364
N	107	71	114	53	47	37	22	49	59	44	24	89	154	55	381
O	97	69	112	61	45	34	28	49	57	47	33	89	132	55	363
P	91	81	128	45	41	35	43	47	79	69	20	102	106	53	362
Q	101	71	135	46	61	50	40	57	71	59	47	81	127	57	378
R	105	73	127	67	65	52	47	53	67	59	42	81	119	71	382
S	63	59	105	57	41	43	40	49	56	43	37	79	117	45	328
Average	**81**	**59.21**	**108.47**	**54.68**	**43**	**38**	**42**	**44**	**66**	**50**	**32**	**88**	**122**	**60**	**352**

*CD = Closure duration, /N/ = nasal mora phoneme

<Slow rate>

Sequences	/kaN/	/kaN/+/to/	/kaNda/	/kana/	/kana/					/kaNna/					
Segments / Informants	/N/	Pause after /N/	/N/	/n/	CD	/k/	/a/	/n/	/a/	CD	/k/	/a/	/Nn/	/a/	Whole
A	89	61	110	67	67	29	53	53	71	67	35	122	118	75	420
B	57	53	102	63	61	37	51	53	67	63	32	112	110	75	400
C	83	93	116	61	35	33	61	37	83	71	37	83	165	83	451
D	89	83	120	43	41	43	49	39	100	63	35	83	173	73	441
E	85	73	148	57	63	49	40	59	77	89	49	89	152	69	456
F	124	63	180	59	61	24	45	51	79	53	53	81	142	69	407
G	97	61	111	73	45	27	65	49	83	57	32	103	154	69	430
H	95	53	132	59	39	38	51	41	86	57	32	101	148	69	413
I	87	57	122	59	32	47	55	36	73	41	26	101	168	81	424
J	81	65	122	39	49	45	45	39	71	45	41	102	130	71	398
K	81	89	120	47	39	63	41	51	71	49	35	106	138	80	410
L	95	105	144	77	59	47	30	53	79	51	45	89	174	67	438
M	77	74	124	67	43	41	26	57	71	51	45	81	178	63	426
N	61	60	94	59	47	39	43	41	83	65	39	90	118	100	421
O	65	81	128	53	49	37	41	41	77	77	33	104	110	87	423
P	135	117	174	71	79	55	65	67	103	69	49	99	150	85	450
Q	164	99	170	65	103	59	53	63	111	71	55	99	176	79	495
R	77	93	124	63	41	28	71	49	79	45	37	110	134	71	407
S	81	67	152	53	51	22	59	47	92	45	28	106	132	106	423
Average	**90.7**	**76.15**	**131.21**	**59.74**	**53**	**40**	**50**	**49**	**82**	**59**	**39**	**98**	**146**	**77**	**421**

References

Han, M. (1962) "The feature of duration in Japanese," *Onseinokenkyu* ('Sounds Study') 10, pp.65-80.

Hirata, O. (1931) "Kokugo no hatsuon ni tsuite" ('On the pronunciation of the Japanese mora nasal /N/'), *Onseinokenkyu* ('Sounds Study') No.4, pp.35-53.

Homma, Y. (1981) "Durational relationship between Japanese stops and vowels" Journal of Phonetics 9, pp.273-281.

Kindaichi, H. (1958) "The sounds /N/ and /Q/," The National Language and Literature No.6, In *A Study of Japanese Phonology* (1977), pp.154-167. Tokyodo Press.

Kuribayashi, H. (1991) "Phonetic characteristics of /N/ and /Q/ in Japanese," The Journal of Nihon University *Gobun* Vol. 80, pp.52-62.

Martin, S. E. (1952) "Morphophonemics of standard colloquial Japanese," *Language* 28, 3 (Part 2): pp.3-115.

Nakajo, O. (1989) *Nihongo no Onin to Akusento* ('Japanese phonology and accent'), Tokyo: Keiso Shobo Press

Port, R., J. Dalby and M. O'Dell et al. (1987) "Evidence for mora timing in Japanese," *Journal of Acoustic Society of America* 81, pp.1574-85.

Poser, W. J. (1990) "Evidence for foot structure in Japanese," *Language* 66, pp.78-105.

Sato, Y. (1990) "A spectrographic analysis of the duration of the mora nasal in Japanese," *Bull. Phon. Soc. Japan* 193, pp.12-17.

Vance, T. (1987) *An Introduction to Japanese Phonology,* Albany: State University of New York Press.