

On the Difference in Schwa Produced by Native Speakers of English and Japanese Speakers of English

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1. Introduction

English is classified as a stress-timed language whereas Japanese is a mora-timed language. Stress-timed rhythm consists of an alternation of weak and stressed syllables. In stress-timed languages, stressed syllables occur in the stream of speech at an equal interval of time called an inter-stress interval (ISI) or a foot. On the other hand, in mora-timed rhythm, syllables are regularly produced at an equal interval of time as in syllable-timed rhythm (Abercrombie, 1965, 1967; O'Connor, 1973). Due to the influence from Japanese phonology, Japanese speakers of English (JS) are likely to produce all syllables in an approximately equal duration and seem to have difficulty in producing weak syllables as opposed to stressed syllables. To speak intelligible English for listeners, however, it is crucial for them to make clear distinction in terms of vowel length between stressed and unstressed syllables in English (Taylor, 1984). Roach (1999) mentions that since native speakers of English (NS) feel that pronunciation without weak sounds is unnatural to native speakers' ears, NNS should learn weak forms as well. Other researchers argue that suprasegmentals such as stress and rhythm, where schwa plays an important role, have been found to influence NS's comprehensibility of L2 English (Anderson-Hsieh, Johnson, & Koehler, 1992; Munro & Derwing, 1995, 1998). The purpose of this study is to compare schwas produced by NS and JS in terms of quality and quantity and demonstrate how difficult it is for JS to produce schwa properly.

The first experiment is designed to investigate schwas located in different positions in words, comparing them produced by NS and JS. Past researchers have not investigated schwa produced by non-native speakers, considering its position in words. This experiment is worth conducting because the difference between schwas produced by NS and JS might be influenced by the position of schwa in a word due to the difference in rhythm between English and Japanese. Another experiment, based on the previous study (Lee, et al., 2004), compares the quality of schwas with the spellings of schwa in the orthography produced by both NS and JS groups. The study showed that NS produced the unstressed vowels in a centralized manner regardless of the orthographic representation. On the other hand, JS's schwas were dispersed in the vowel space according to Japanese orthographic representations. The second experiment compares schwas produced by NS and JS, focusing on whether or not the number of syllables in ISI affects the duration of schwa. Since schwa is closely related to stress-timed rhythm, this experiment might reveal the different

realization of schwa under the different rhythms. The same data used above is also used to explore the effect of speech rate on schwa in length produced by NS and JS. The results will be discussed by means of co-articulation and language rhythm.

2. Characteristics of schwa

We shall now take a closer look at the reduced vowel, schwa. Several attempts have been made by past scholars to show the characteristics of schwa. In recent decades, much attention has been paid to whether or not phonetic realization of schwa is due to centralization or assimilation to context (Gimson, 1980; Crystal, 1985; Nord, 1974; Magen, 1989; Bergem, 1993, 1994; Bate, 1995). This controversy seems to have come to an end with the finding that both centralization and contextual assimilation are observed (Browman & Goldstein, 1992). A subsequent study conducted by Kondo (1995) demonstrated more specifically that the quality of schwa is targeted in the first formant frequency (F1) but affected by surrounding sounds in the second formant frequency (F2).

A number of studies have been made on the duration of schwa. Oller (1973) and Lehiste (1975) revealed that there is a 65% duration decrease when vowels are unstressed. Liberman (1960) compared the vowels with and without stress in words of stress pairs. (e.g. CONtrast vs. conTRAST). He found that a vowel with a stress is longer than that without it by 66% in duration. Wallace (1994) paid attention to the duration of schwa in the different position located in a word and found that the duration is relatively short in word-initial and word-internal syllables, compared to that in word-final syllables.

Previous studies have indicated that speech rates affect the duration and quality of vowels. Although there are some studies on the relations between speech rate and full vowels (Gay, 1978; Tuller et al., 1982; Fourakis, 1986; Crystal and House, 1988a, b; Fourakis, 1991), there are few studies that examined a reduced vowel schwa (van Son and Pols, 1992). They demonstrated that the duration of schwa has nothing to do with speaking rate in Dutch, implying that this is due to the fact that schwa is characteristically short by nature.

3. Second language acquisition of schwa

Only few studies have investigated the acquisition of schwa by L2 learners. Kondo (1995) studied the acquisition of schwa by JS from the perspective of co-articulation. She argues that the difference of co-articulation patterns stems from the difference in linguistic rhythm. English rhythm is characterized by an alternation of full and reduced vowels. The quality of full vowels of English seems to be less assimilated to the surrounding phonemic context, but this is not the case for the reduced vowel (Fowler, 1981, Magen, 1984, Kondo, 1994, Bates, 1995). As for Japanese, all the vowels are less affected by the surrounding sounds (Beckman & Pierrehumbert, 1986; Kondo, 1995). In other words, the two languages employ different co-articulatory strategies. Therefore, in order to produce schwa intelligibility it is crucial for JS to acquire the co-articulatory patterns of L2 (Kondo, 1995).

Based on Kondo's (1995) study, Akita (2001) conducted a longitudinal study on the acquisition of segments and prosodic features produced by JS. She concluded that learners who had succeeded in acquiring vowel reduction also achieved the correct timing of pitch

pattern in the target language, demonstrating the interaction between a segmental process and a prosodic process.

Lee et al. (2004) acoustically examined the production of unstressed vowels in English by early and late Korean-English and Japanese-English bilinguals. They found that the quality (F1 and F2) of the unstressed vowels produced by NS were centralized. Unstressed vowels produced by late Japanese bilinguals, however, were located in the peripheral area of the vowel spaces, which are in accordance with the Japanese orthographic representations. They explained that this is probably due to no central vowel in Japanese. As to the durational control between stressed and unstressed vowels, the production of schwa by JS was native-like because of the positive transfer from L1 Japanese, which has the phonemic contrast in vowel length. The experiment did not consider the position of schwa in a word, i.e. initially, medially and finally. Since Japanese is a mora-timed language, where each syllable is equal in duration, it could be assumed that JS might transfer this characteristic to the L2, for example, producing a longer duration of schwa in a word-initial position.

With respect to the relationship between speech rate and the duration of schwa in L2 acquisition, no study has been conducted so far. It seems to be universal that a vowel in syllables is likely to be reduced in any languages when speech rate increases (Bergem,1994). It is unknown, however, whether or not JS can manipulate the duration of schwa according to the speech rate since schwa does not exist in Japanese. In the relations between voice onset time (VOT) and speech rate, Schmidt and Flege (1996) provided the finding that speaking rate affects stops in the production by Spanish and English monolinguals and Spanish English bilinguals. They revealed that NS and the bilinguals who began learning English as adults produce longer VOT as speech rate increases. On the contrary, the bilinguals who started learning English as adults held constant duration across speaking rates and showed a quite variable performance. Given that result, it could be assumed that a JS who started their study after a critical period might have difficulty in controlling the duration of schwa regardless of the speech rate.

Examining the durational manipulation between stressed syllables and unstressed syllables in ISI is useful to see whether or not L2 learners whose native language is mora-timed have acquired stress-timed rhythm. Mochizuki-Sudo and Kiritani (1991) demonstrated that unlike native speakers of English, non-proficient JS have difficulty in controlling the duration of ISI by compressing the stressed vowels when unstressed syllables are added. As for the experiment on perception, NS tend to allow durational compensation between unstressed syllables and stressed syllables. This indicates that ISI is a temporal unit in production and perception for NS, but this is not the case for non-proficient JS. Since their study mainly focused on stressed vowels in ISI, it is crucial to take a closer look at the realization of the weak vowel in ISI as well.

4. Experiment 1: schwa in content words

4.1 Research questions

The present experiment here compares the schwas produced in content words by NS and JS. One of the purposes for this experiment is to investigate the difference in schwa duration

between NS and JS. It is also of interest to know whether schwa duration is influenced by the position of schwa in a word. As for vowel quality, it is investigated through the relations between native languages' orthography and the quality of English schwa in both cases of NS and JS, replicating the results in Lee et al.(2004). More specific research questions are as follow:

- 1) Are there any differences in the duration of schwa (which is located in the initial, medial and final position of a word) between NS and JS?
- 2) Are there any differences in the quality of schwa (which is transcribed in various orthographic spellings, a, e, i and o) between NS and JS?

4.2 Participants

Three NS and seven JS participated in this experiment. NS teach English at universities in Japan. As for JS, three of them are professors who teach English at a college or university in Japan, and the rest of the JS are graduate students who study linguistics or teach English in Japan. The JS English levels are advanced. The duration of living in English spoken countries is varied, from 2 years to more than 10 years. None of the participants have speech, language or hearing problems.

4.3 Materials

The material consists of 12 words (see Table 1), and each word contains at least one reduced vowel. The locations of schwa in words are varied; initial, medial and final position. The participants were asked to produce the 12 words in a carrier sentence, *I said _____ this time* twice. Main stress is marked in bold and schwa is marked in color in each word written on a card.

4.4 Procedures

The utterances produced by participants' productions were recorded on a personal computer in a quiet room. Two acoustic measurements were conducted. One is for the duration of schwa and primary stressed vowels. The other one is for the first and second formant frequencies (F1 and F2) of the reduced vowels. For the durational analysis, the ratio of the reduced to the stressed vowel in a target word was calculated. In terms of vowel quality, numerical values of F1 and F2 were normalized for the spectral analysis of the target vowels and schwa to avoid the effect of the difference of vocal tract lengths in each participant. All the formant values were normalized to one female NS speaker, referring to the average the third formant frequency (F3) of [i] in the words used in Experiment 1. The mean F3 of this speaker was taken as the norm and was divided by the mean F3 for each participant. Then, the formants for each speaker were multiplied by the factor derived from their own F3. The statistical analysis of Mann-Whitney test was used to examine whether or not significant differences between the production of NS and JS exist.

Table 1 List of English words used in Experiment 1

<i>Initial</i>	<i>Medial</i>	<i>Final</i>
<u>e</u> leven	econ <u>o</u> my	o <u>p</u> era
a <u>b</u> ility	intro <u>d</u> uce	so <u>f</u> a
a <u>ff</u> ord	tele <u>v</u> ision	
<u>o</u> bject (verb)	kangar <u>o</u>	
as <u>l</u> eep	indicate	

underlined letters =schwa , emphasized letters = primary stress

4.5 Results and discussion

Schwa in the different word position

Figure 1 presents the mean ratios of reduced to stressed vowels produced by NS and JS. The result shows that the schwa produced by JS is relatively similar to that of NS, indicating that the schwa in the final position of words is longer (NS: 112 %, JS: 111 %) compared to the ones in the initial and medial positions of words (NS: 48 %, JS: 53 % for the schwa in the initial, NS: 49 %, JS: 50 % for the schwa in the medial position). Mann-Whitney test revealed that there is no significance between the duration of schwa produced by NS and JS in each position, indicating that $F(1, 98) = .39, p > .05$ for the schwa in the initial position, $F(1, 55) = .944, p > .05$ for that in the medial position, and $F(1, 20) = .954, p > .05$ for that in the final position. It should be noted, however, that the duration of schwa in the initial position produced by JS seems to be somewhat longer than that of NS (NS: 48%, JS: 53%), showing that the rhythm consisting of “weak syllable and strong syllable” (WS) by JS is still not perfect. But it is not clear whether this phenomenon stems from the transfer of L1 or the constraint of universal language acquisition. As to the schwa in the

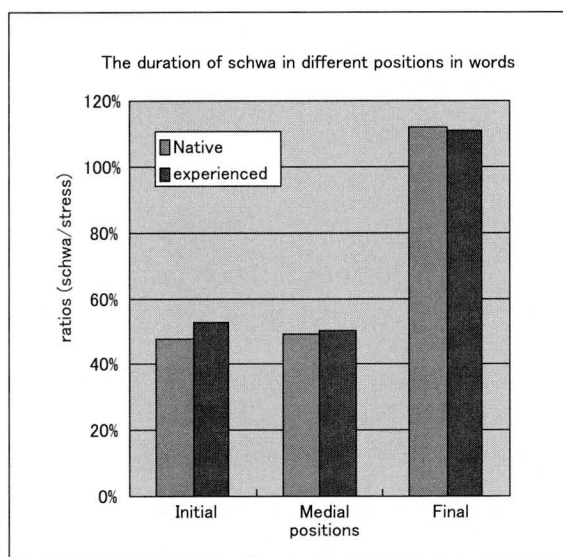


Figure 1 Duration of schwa in different positions in words

final position, both NS and JS produced schwas longer compared to the ones in the other positions, which supports the previous study made by Wallace (1994). The reason why JS can produce native-like schwa in the final position could be explained by means of final lengthening. Although whether or not Japanese language has final lengthening is still argued, a recent study (Ota et al. 2003) confirmed the final lengthening in Japanese. It could be, therefore, assumed that JS positively transferred the characteristics of schwa to their English.

Schwa corresponding to different spellings in orthography

To statistically compare the normalized first and second formants of schwa with each spelling of “a”, “e”, “i” and “o” produced by NS and JS, Mann-Whitney test was conducted. T-value with an asterisk in Table 2 shows the significance at $p < .05$. There is a significant difference between the second formant of the schwa spelt only in the letter “a”. This result, in part, supports the previous study by Lee et al. (2004), where Korean and Japanese late bilinguals show significant differences from native speakers in the quality of reduced vowels spelt as “i”, “e”, and “a”. It could be assumed that the schwa spelt as “a” produced by JS is likely to deviate in quality from the one by NS. The reason for this is open for future research.

Table 2 Results of Mann-Whitney test performed on the quality of schwa (F1, F2)

F1	F2
a : $p=.454 <.05$ (n.s) df (118)	a: $p=.032 <.05^*$ df (118)
e : $p=.929 >.05$ (n.s) df (38)	e: $p=.239 >.05$ (n.s) df (38)
i : $p=.547 >.05$ (n.s) df (38)	i : $p=.207 >.05$ (n.s) df (58)
o : $p=.929 >.05$ (n.s) df (58)	o: $p=.449 >.05$ (n.s) df (58)

5. Experiment 2: schwa in function words

5.1 Research questions

The second experiment investigates the production of schwa in function words produced by NS and JS. It is of interest to examine whether or not the number of syllables in ISI and speech rates affect the duration of schwa. Specific research questions are as follow:

- 1) Does the number of syllables in ISI affect the duration of schwa produced by NS (When the number of syllables decrease from three to two, will the target unstressed vowel, schwa, be longer or not?)
- 2) Does the number of syllables in ISI affect the duration of the target produced by JS?
- 3) Does speech rate affect the duration of schwa in the case of NS?
- 4) Does speech rate affect the duration of the target produced in the case of JS?

5.2 Participants

Four NS who are currently teaching at universities in Japan and four JS who are graduate students majoring in linguistics or English education in Japan participated in this experiment. The latter ranked as being at an advanced level of English. None of the participants have any speech, language or hearing problems.

5.3 Materials

Four sets of English sentences, twelve in total, were used (see Table 3). The sentences in each set differed in the number of unstressed syllables that were intervened between a target stressed syllable and the next stressed syllable. The number of unstressed syllables in all sets ranged from one to three. The target for the analysis is schwa in the function word “the”. Two sets of sentences contained two different types of stressed vowels; tensed vowel, (/oo/, /u:/) and lax vowel (/ɪ/, /e/). The four sets of sentences are listed in the table below. Italicized parts are the target ISI (inter-stress interval).

Table 3 Materials for Experiment 2

- | | |
|--------|--|
| <Set1> | (1) I'm going to miss <i>the</i> beauty spots in England. ((2 syllables in ISI)) |
| | (2) I'm going to miss <i>all the</i> beauty spots in England. ((3 syllables in ISI)) |
| | (3) I'm going to miss <i>some of the</i> beauty spots in England. ((4 syllables in ISI)) |
| <Set2> | (1) I wrote <i>the</i> Christmas cards yesterday. ((2)) |
| | (2) I was <i>writing the</i> Christmas cards yesterday. ((3)) |
| | (3) I wrote <i>some of the</i> Christmas cards yesterday. ((4)) |

- <Set3> (1) I'm going to *send the* files to the language department. ((2))
 (2) I'm *sending the* files to the language department. ((3))
 (3) I'm going to *send some of the* files to the language department. ((4))
- <Set4> (1) He *fooled the* girls in his class. ((2))
 (2) He was *fooling the* girls in his class. ((3))
 (3) He *fooled some of the* girls in his class. ((4))

5.4 Procedures

The participants were instructed to produce the sentences at two types of speaking rate: slow (at the speed of talking to non-native speakers or students) and normal (at the speed of talking to native speakers of English). They were also asked to read each sentence through without a pause. When they inserted a pause or made mistakes, they were asked to repeat the sentence from the beginning. They repeated the text twice. Before the recording, they were given enough time to practice the sentences. One native speaker of English who has knowledge of linguistics and one non-native philologist checked whether the stress-marked vowels on the lists would be produced with appropriate prominence by subjects.

5.5 Results and discussion

The number of syllables in ISI

Figure 1 shows the percentage of the occurrence of shortening of the stressed vowel and the schwa within ISI when the number of syllables in ISI increases from two to three. As shown in Table 4, NS shortened the stressed vowel as the number of the syllables in ISI increased, but they seem to have produced the schwas with a comparatively consistent duration regardless of the number of syllables in ISI. The results of JS are different from those of NS. First of all, the duration of schwa was variable depending on individuals: half of the participants shortened the target weak vowels and the others lengthened them when the number of syllables increased in ISI. As for stressed vowels, two Japanese participants out of four produced stressed vowels longer as the number of syllables increased as opposed to the realization of stressed vowels by NS.

Table 4 Average percentage of the occurrence of shortening of the stressed vowel and schwa in ISI when the number of syllables increased from two to three

	Slow Stressed	Slow Schwa		Slow Stressed	Slow Schwa
NS1	80%	106%	JS1	120%	85%
NS2	70%	89%	JS2	121%	113%
NS3	81%	114%	JS3	123%	89%
NS4	52%	89%	JS4	79%	102%
Average	71%	100%	Average	111%	97%

	Fast Stressed	Fast Schwa		Fast Stressed	Fast Schwa
NS1	105%	108%	JS1	132%	89%
NS2	103%	109%	JS2	113%	153%
NS3	73%	101%	JS3	83%	95%
NS4	65%	100%	JS4	87%	109%
Average	87%	105%	Average	104%	112%

One hypothesis worth considering is that the duration of schwa is independent of the number of syllables in ISI when other factors which affect the duration of schwa such as segmental environment, stress and etc. are controlled. This implies that NS preserve the timing of the gestures of schwa. However, additional research is needed here to validate this argument. As for JS, they seem to be unable to do durational controls between stressed and unstressed vowels in ISI, and this suggests that they have not yet acquired English rhythm although their English is at an advanced level.

Speech rate

Figure 2 shows the mean duration of schwa produced at the two speaking rates (fast and slow) Slow-rate schwa was longer than fast-rate schwa in both NS and JS groups. The schwa produced by NS at a fast rate was 7msec.shorter than the schwa produced at a slow rate. As to the schwa produced by JS, it was 9 msec. shorter than that produced at a slow rate.

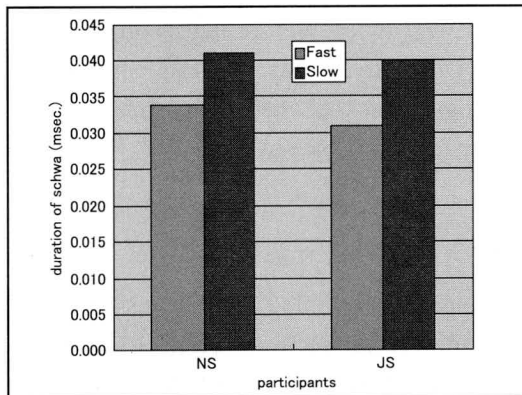


Figure 2 Mean duration of schwa produced at the two speaking rates

Table 5 Speech rates of the participants

	Fast(slb./sec.)	Slow(slb./sec.)
NS1	3.27	5.49
NS2	4.42	5.28
NS3	4.97	5.35
NS4	4.50	5.50
JS1	5.00	4.00
JS2	4.63	2.79
JS3	5.19	4.05
JS4	4.42	4.12

As shown in Figure 3, all the participants, except NS4, differentiated the duration of schwa in production between the two different speech rates. The previous study on the relations between the duration of VOT and speech rates demonstrated that the late bilinguals of Spanish and English, who had begun learning English as adults, showed smaller effects of speaking rate on VOT than NS did. This experiment showed that the duration of schwa produced by NS and JS seem to have influenced by speech rates.

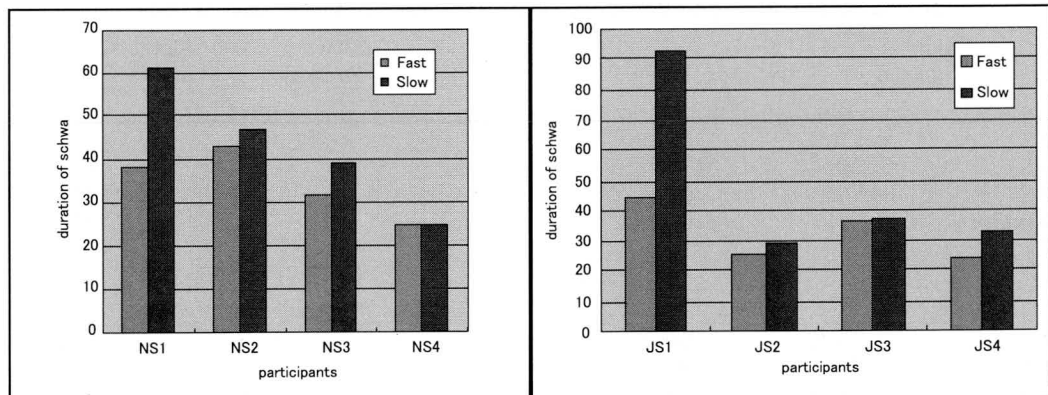


Figure 3 Mean duration of schwa produced by NS & JS at the two speaking rates

Why did JS in this study reduce the duration of schwa when the speech rate increased in the same way as NS? A researcher mentioned that in any language all vowels produced at a spontaneous speech are sometimes acoustically reduced (Bergem, 1995). Therefore, it is perhaps natural for JS to shorten the duration of English vowels in accordance with the speech rates.

As was revealed in the aforementioned study on speech rate and the vowels of Dutch, the researcher maintained that the duration of schwa did not differ across speaking rates because schwa is very short by nature. The results obtained from this experiment, however, show that the participants changed the duration according to the given speech rate except NS4. At first, I assumed that the speech rates did not appear to affect the duration of schwa in the experiment in Dutch because the difference of the two speech rates was not large enough. This assumption, however, does not seem to be correct. In this experiment, the participant who did not make a great difference between the fast and slow speech modes—4.97 sylb./msec. in the fast speech style and 5.35 sylb./msec. in the slow speech style—was even able to produce schwa differently in duration between the two speech rates. Alternate explanation is that the study of schwa in Dutch was limited in that only one speaker participated in the experiment in which a single text was read aloud. Schouten and Pols (1979) claimed that inter-speaker variation is greater in the isolated speech mode than in the connected speech mode. Therefore, it could be said that the difference in the effect of speech rate on the duration of schwa is partly due to “speaker effect”. Further investigation will be needed here.

6. Conclusion

6.1 Summary

The main purpose of this study was to compare schwas produced by native speakers of English and Japanese speakers of English. The results presented here indicate that it is not easy even for advanced JS to produce schwa correctly in terms of its quality and duration. The results of Experiment 1 suggest that advanced JS are able to produce schwa correctly in length. This can be accounted for by postulating the L1 transfer of phonemic distinction in length to the L2 production (Lee et al., 2004). JS seem to have difficulty, however, in producing schwa correctly in quality, and this could be explained in terms of different co-articulation patterns between English and Japanese (Kondo, 1995). Experiment 2 demonstrates that JS cannot manipulate the duration of schwa and the stressed vowel in ISI in the same way as NS do when the number of syllables in ISI increases. This is probably due to the fact that JS have not fully acquired English rhythm. As to the relationship between speech rate and the duration of schwa, the duration of a schwa shortened when the speech rate increased in both groups. This result could be explained by the universal phenomenon that vowels are reduced as speech rate increases.

6.2 Limitation and further study

A limitation of the present study should be addressed here. In Experiment 2, some participants produced a different rhythmic sequence in the target sentences against the

researchers' expectation. For example, in the sentence, "I'm going to *miss some of the* beauty spots in England. ((4 syllables ISI))", where the researcher expected the participants to read the italicized part as four syllables, some of the participants located an intonation boundary after "miss" and divided the target ISI into two parts, that is, "miss" (one syllable) and "*some of the*" (three syllables). The researcher checked the naturalness of the materials with a native speaker of English. However, the naturalness of the number of syllables within a target ISI seems to be varied depending on the participants, and the target ISI containing four syllables did not work well for this experiment.

Further research is needed to investigate the acceptable ranges of the quality of schwa and durational ratios between schwa and a stressed vowel within ISI for native and non-native listeners. Such a study would be able to provide the criteria for intelligible communication in English.

6.3 Pedagogical implication

In the past few years, researchers have claimed that inaccurate L2 suprasegmentals might contribute to a greater extent to foreign accent as compared to inaccurate segmental production (Anderson-Hsieh et al, 1992; Koster & Koet, 1993; Munro, 1995). With regard to the fields of teaching and learning pronunciation, a top-down approach, namely, that of focusing more on suprasegmentals involving global meaning and communication has been adopted, as against adherence to the traditional bottom-up, phonemic-based approach, which is based on isolated or contrasted sounds (Chun, 1998).

In terms of English education in Japan, the aspect of suprasegmentals in teaching pronunciation has attracted considerable attention among teachers from junior high schools to colleges. The trend of implementing the "shadowing" activity—which has been stated as being effective for improving L2 learners' listening skills and prosody such as rhythm, stress, and intonation (Tamai & Kadota, 2004)—has seemed to contribute to making teachers focus their attention on the aspect of suprasegmentals in teaching pronunciation. In shadowing, an activity that was originally developed for training interpreters, learners simultaneously repeat what they hear in English without referring to a text. Researchers claim that in order to successfully implement this activity, while shadowing, it is important to pay "attention" to specific suprasegmental features such as stress, intonation, and so on.

In an attempt to acquire "stress"—where schwa plays an important role—paying "attention" to the coarticulation of sounds through the shadowing activity would be crucial. It would be beneficial if learners could visualize the sequence of the tongue movement: they move their tongues within their mouths to create a variety of sounds and then quickly bring their tongues back to the home base, that is, the position of making the sound of schwa. In other words, this movement is comparable to a string of rubber that is stretched out by a finger; when released by the other fingers, this stretched-out rubber returns to the finger holding it. Since schwa is greatly affected by the surrounding sounds, it is perhaps very important for learners to consciously implement the coarticulatory strategy instead of

focusing on implementing individual sounds. In this manner, they would be able to produce native-like schwa and stress.

As mentioned earlier, since the coarticulation strategy of English is extremely different from that of Japanese, the acquisition of this strategy would be a difficult task for JS. Therefore, as shown in the present study, even those JS whose English was at an advanced level could not produce a native-like sound of schwa in its quality. The conscious implementation of practices for the coarticulation strategy through shadowing would help JS to acquire the native-like schwa.

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